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Intelligent Tutoring System Effects on the Learning Process

A thesis submitted in partial fulfillment of the
requirements for the degree of
Master of Science in Computer Engineering

By

ALI TALIB QASIM AL-AQBI
B.Sc., University of Technology, 2010

2017
Wright State University

WRIGHT STATE UNIVERSITY

GRADUATE SCHOOL

July 27, 2017

I HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER MY SUPERVISION BY Ali Talib Qasim Al-aqbi ENTITLED Intelligent Tutoring System Effects on the Learning Process BE ACCEPTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF Master of Science in Computer Engineering.

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ABSTRACT

Al-Aqbi, Ali Talib Qasim. M.S.C.E. Department of Computer Science and Engineering, Wright State University, 2017. *Intelligent Tutoring System Effects on the Learning Process.*

The traditional education systems that have been used for several centuries have evolved very slowly and might be ineffective for addressing diverse learning styles and levels of preparation. This system is characterized by many students interacting with a single teacher, who is unable to address the individual needs of every student. Therefore, some students can become frustrated and fail to reach their educational potential. An Intelligent Tutoring System (ITS), which is a computer application used to provide students with one-to-one supplemental tutoring tailored to the student's learning style and pace, is of interest to educators for improving student learning. To evaluate the effectiveness of ITS, a systematic review of the recent literature was performed using a carefully crafted protocol designed to provide data to support a meta-study of the effectiveness of ITS. The research question guiding this study is: "Does an intelligent tutoring system improve students' learning abilities more than traditional learning?" A t-test, one-way ANOVA test, and KNIME program that does Latent Dirichlet allocation were performed. The results support the conclusion that ITS causes a significant improvement in learning over traditional instructional methods.

TABLE OF CONTENTS

Chapter 1: INTRODUCTION.....	1
1.1 Background.....	1
1.2 Context	2
1.3 Thesis Goal	4
1.4 Significance	5
1.5 Scope of the Thesis	6
1.6 Thesis Outline	6
Chapter 2: LITERATURE REVIEW	7
2.1 Systematic Review	7
2.1.1 Planning the Review.....	7
2.1.2 Conducting the Review	9
2.1.3 Documenting the Review	9
2.2 Historical View of the Mechanical System [14].....	10
2.2.1 Computer Assisted Instruction (CAI)	11
2.2.2 Intelligent Computer Assisted Instruction (ICAI)	13
2.2.3 Artificial Intelligence and Education	14
2.3 Intelligent Tutoring Systems.....	14
2.3.1 Introduction to Intelligent Tutoring Systems.....	14

2.3.2 Architecture of Intelligent Tutoring System.....	16
2.4 The Domain Module	17
2.4.1 Domain Module Approaches	18
2.5 Student Module [8]	21
2.5.1 Student Module Concepts.....	22
2.6 Teaching Module [8].....	26
2.6.1 Feedback.....	27
2.7 Communication Module [23].....	27
2.8 Examples of Intelligent Tutoring Systems	28
2.8.1 WhaleWatch [25]	28
2.8.2 Pump Algebra Tutor (PAT) [23].....	30
2.8.3 AutoTutor [26].....	32
2.8.4 Cognitive Tutor Algebra I Program [27].....	33
Chapter 3: METHODOLOGY	35
3.1 Background.....	35
3.2 The Research Questions	36
3.3 Search Process	36
3.4 Study Selection Criteria.....	38
3.4.1 Inclusion and Exclusion Criteria.....	38
3.5 Study Selection Procedures	39
3.6 Study Quality Assessment Checklists and Procedures.....	39
3.7 Data Collection	40

3.8 Data Synthesis.....	41
3.9 Reporting the review (Dissemination)	41
Chapter 4: RESULTS	42
4.1 Results (Mean and Standard Error of the Mean)	42
4.2 Results (t-test and one-way ANOVA test)	48
Chapter 5: LATENT DIRICHLET ALLOCATION	51
5.1 Latent Dirichlet Allocation	51
5.1.1 Topics	51
5.1.2 Model.....	51
5.1.3 Generative Process	53
5.1.4 Working Backwards.....	54
5.2 KNIME Analytics	54
5.2.1 KNIME Components.....	55
5.3 The Result Obtained from KNIME	57
Chapter 6: DISCUSSION AND CONCLUSION	61
6.1 Discussion.....	61
6.2 Conclusion	66
6.3 Future Work.....	67
REFERENCES.....	68
Appendix A.....	77
- Publication year	77
- Studies Summary	78

LIST OF FIGURES

Figure 2.1 CIA chart	13
Figure 2.2 The ITS components	16
Figure 2.3 WhaleWatch	29
Figure 2.4 PAT tutor	30
Figure 3.1. The search strategy	37
Figure 4.1 Computer Science mean and standard error of the mean for ITS and control group	43
Figure 4.2 Physics mean and standard error of the mean for ITS and control group	44
Figure 4.3 Mathematics mean and standard error of the mean for ITS and control group.	45
Figure 4.4 Physiology mean and standard error of the mean for ITS and control group. .	45
Figure 4.5 Accounting mean and standard error of the mean for ITS and control group.	46
Figure 4.6 Reading mean and standard error of the mean for ITS and control group	47
Figure 4.7 All studies' mean and standard error of the mean for ITS and control group. .	47
Figure 5.1 LDA plate notation	52
Figure 5.2 KNIME program	55
Figure 5.3 KNIME components that are used in this thesis.	55
Figure 5.4 The mean and the standard error of the mean for topic 0.	57
Figure 5.5 The mean and the standard error of the mean for topic 1.	58
Figure 5.6 The mean and the standard error of the mean for topic 2.	59

Figure 6.1 Retention [32].....	62
Figure 6.2 Retention for [33]	62
Figure 6.3 Weak students' improvement in study 2 of [37].....	64
Figure 6.4 Weak students' improvement in study 3 of [37].....	64

LIST OF TABLES

Table 1. A Comparative Overview of Students' Mean Scores and Their t-test Results ...	48
Table 2. Statistical Analysis of the Mean Scores for ITS and Control Group	49
Table 3. T-test for the Topics	59
Table 4. ANOVA Test for the Topic	60
Table 5. Studies' year of publication and their percent from the whole papers	78

DEDICATION

To my wife Nadia and my daughter Eileen

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CHAPTER 1: INTRODUCTION

The traditional education systems that have been used for several centuries have evolved very slowly and might be ineffective for addressing diverse learning styles and levels of preparation. This system is characterized by many students interacting with a single teacher, who is unable to address the individual needs of every student. Therefore, some students can become frustrated and fail to reach their educational potential. Intelligent Tutoring System (ITS), which is a computer application used to provide students with one-to-one supplemental tutoring tailored to the student's learning style and pace, has been of interest to educators for improving student learning.

1.1 Background

The use of computers in the learning process has been an area of interest to education researchers for nearly a century. The goal of those researchers has been to build computing systems that help students to learn about specific domains. One of the earliest computing systems in education, such as the instructional machine of Pressey in 1926, posted multiple-choice questions with answers provided by teachers. Advancements in computing technology led to the introduction of artificial intelligence (AI) in these systems in the 1970s, the integration of which was called *intelligent tutoring systems* (ITS). ITS has evolved, and this software can model the cognitive and emotional states of learners with the goal of adapting and personalizing instruction [1]. These systems have been used in the education system in many domains, such as physics, chemistry, mathematics, and

computer science. Even though a large number of ITS have been developed, most of these systems are used only in the research environment because of the difficulty in developing them and the complexity required to provide flexible and robust systems [2]. ITS can be the solution for the many challenges faced by education systems; one of the biggest advantages of the ITS is the one-to-one teaching environment that it provides.

1.2 Context

For centuries, a traditional education system has been used that is characterized by classrooms with chalk or whiteboards as their focal point and several students taught as a group by one teacher. These elements of the traditional education system have created significant challenges. For example, the large number of students (often more than 20 students) in a classroom prevents the teacher from giving his/her attention to every individual student in the class.

The traditional education system creates an environment in which it is difficult to accommodate students' varying levels of background information about the materials and differences in their ability to learn; the teacher uses the same materials and teaching techniques for the entire class regardless of the students' different levels of understanding. This problem can lead to some students becoming frustrated because not all students learn from the same teaching style; some are visual learners, some are auditory learners, etc. Students in these traditional classrooms often concentrate more on taking notes than spending time on understanding the materials, making it more difficult for students to master the concepts. This problem is exacerbated by the limited time the teacher has for lecturing over the content such that the majority of class time is dedicated to lectures

instead of to active learning. Students' lack of time to practice can lead to a large number of students who do not know how the information covered in lectures could be applied.

The traditional educational system has been used for centuries but is now considered an inflexible learning environment because all of the control over learning goes to the teacher [3]. In America for example, the traditional education system has created significant deficits leading to a high number of American people who are going to be illiterate in virtual science and technology. Many high school graduates have fewer skills than their parents. In contrast, many Japanese students score 100% better in mathematics than the average American student. Furthermore, not all American teachers are qualified to teach the courses that they are teaching [4].

College students have different backgrounds, education levels, and requirements for learning. Depending on the traditional ways of delivering information to students is not a sufficient teaching technique. In addition to the problems previously mentioned, other obstacles faced by students include feeling bored by lecture-driven teaching, feeling rushed because the teaching time is limited, or becoming frustrated because the course material is hard to understand. Furthermore, there are often limited educational resources available to students outside of the class. Moreover, large classes sometimes cause delays in teachers providing feedback and grades [5]. Also, if students get their copy of the lectures before class, they might study that instead of going to the classroom [6]. Educators must be mindful of these difficulties if they want to build an effective teaching system.

The problems are so complex and pervasive that a solution to improve the education system should be addressed. It is crucial to find a way to make the learning process much more flexible and more motivating for students. The best way to do that is by assigning

one teacher for each student, but this solution also has many disadvantages, the biggest of which is the expense. ITS might be a solution for these problems. ITS is a computer application used to provide students with one-to-one information and hints throughout the learning process about a specific topic [7]; ITS functions as a private tutor. In a study by Shrobe, even though all students spent the same time in learning topics, 98% of students who had their own tutors performed much better than the other students whose learning took place within the traditional educational system [4]. Also, the students who had private tutors scored a four to one advantage compared to the same amount of time that students without tutors needed to get to the same level of proficiency. The ITS can provide immediate feedback to students on every question that has been asked. The immediate feedback and the individualization are so important because teaching will be much more effective when it happens in direct reply to the students' needs [8]. The ITS has four major modules: Domain, Student, Teaching, and Learning Environment [9].

1.3 Thesis Goal

This thesis explores using the ITS to improve education systems and students' level of proficiency. The objective of using ITS in the education system is to help facilitate learning, improve the course navigation, rework the available information and teaching methodology, explain errors to students, and answer any student's questions, etc. [10]. ITS can simplify the learning process. When students answer any question asked by the ITS, their answers will be analyzed. Depending on this analysis, appropriate feedback will be provided to students. As more support, the ITS will give hints to students in every step of their learning process, whether their answers are correct or incorrect. In addition, there could be more support for this teaching process by supplying students with extra web links

for relevant pages. Also, the next step that students should take when learning materials will be chosen by the ITS depending on the student's level of knowledge of the material that they learn. If students could not understand the facts of a specific subject, as often happened in the traditional teaching mode, the ITS would provide students with web links for further information. The ITS would also offer videos for every subject that students study so that in addition to the hints and the links, there would be videos to help students understand the topic effectively.

This goal of this thesis is to answer the following question: Does the ITS improve students' learning abilities more than the traditional learning methods? This thesis answers this question by making a systematic review of numerous studies of intelligent tutoring system's effect on learning in an educational setting.

1.4 Significance

ITS are not widely used by teachers even though they have become more popular in the last decades. There are many reasons for that, but the most important one is that although there are many ITS in the market, few of them have been used in practical teaching. Given the educational advantages of ITS, it is important to integrate them into the learning process so that they will be widely accepted and used by educators. This study contributes to this goal by evaluating whether the use of ITS could enhance learning within traditional educational systems. ITS have a lot of advantages, some of which are explored in this study:

1. It is available at any time, unlike classroom teachers who are available just during school time.
2. It reduces dependency on human resources.

3. It provides an immediate feedback to students and provides hints for students until they become proficient in the material they are learning.
4. It provides a one-to-one teaching environment.
5. It reduces student travel time because the ITS can be done in their homes.

1.5 Scope of the Thesis

This thesis provides an overview of the scientific papers and studies that address ITS and its effect on the education system from 1990 until now. This thesis uses a systematic review of the literature to evaluate the effectiveness of ITS on learning.

1.6 Thesis Outline

This section outlines the remainder of this thesis. Chapter two contains the literature review and a discussion of ITS. Chapter three explains the methodology used to collect the papers and to do the analysis. Chapter four provides the results of the analyses. Chapter five provides an explanation of the latent dirichlet allocation. Chapter six summarizes the study and provides its conclusions.

CHAPTER 2: LITERATURE REVIEW

This chapter describes the systematic review used in this study. It provides a historical overview of ITS, including the first use of computers in learning. It concludes by describing the components ITS and providing several examples.

2.1 Systematic Review

The systematic review is the ability to construct an objective summary of available research evidence [11]. The systematic review differs from a traditional review, which often lacks carefulness and is not accepted as a credible scientific method. A traditional review has limited ability to extrapolate meaning from a collection of studies, and the review can be biased by the researcher [12]. On the other hand, the goal of the systematic review is to provide a synthesis that is complete and unbiased. In addition, the systematic review must be conducted according to a well-defined procedure such that it must be understandable to other researchers [13]. There is a three-step procedure followed in a systematic review: planning the review, conducting the review, and documenting the review.

2.1.1 Planning the Review

This step involves both preparing and confirming a research protocol, and it also requires defining the research question that will be addressed by the review [13]. Planning the review has many associated stages, including identifying the need for a review, commissioning a review, specifying the research question(s), developing a review protocol, and evaluating the review protocol. Identifying the need for a review

arises from the researchers' need to summarize every piece of information about a topic in a way that is considered unbiased. This can be done to make a general conclusion about that topic, which is impossible to have from individual studies [13]. In commissioning a review, many organizations do not have time to collect information to do a systematic review by themselves about a specific topic, so they will commission researchers to do this job. In this case, these organizations must produce a commissioning document specifying the work required [13]. Specifying the research question is the significant part of the systematic review because the question drives the whole systematic review methodology. Developing a review protocol specifies the methods that will be used to undertake a specific systematic review. To reduce the possibility of bias in the research, a predefined protocol is necessary. The protocol that has been used in the methodology of this thesis has 9 steps [13]:

1. The background, which provides the rationale for the systematic review of the effects of the ITS on the education process
2. The research question that this thesis will answer
3. The strategy that will be used to search for primary studies, including search terms and resources to be searched, such as digital libraries, specific journals, and conference proceedings
4. Study selection criteria, which are used to determine which studies are included in, or excluded from this systematic review
5. Study selection procedures, which should describe how the selection criteria will be applied (e.g., how many assessors will evaluate each prospective primary study and how disagreements among assessors will be resolved)

6. Study quality assessment checklists and procedures to guide the development of checklists
7. Data collection methods to define how the information required from each primary study will be obtained
8. Data synthesis to define the synthesis strategy
9. Dissemination strategy

Evaluating the review protocol is an important part of the systematic review. Researchers should agree on a procedure for doing this [13].

2.1.2 Conducting the Review

The review can begin once the specific protocol is determined. I constructed this thesis protocol using these steps: identification of research, study selection, study quality assessment, data extraction, and data synthesis. Identification of research involves finding studies related to the thesis question by using an unbiased tactic. After that, the assessment of these findings should be started to select which one is relevant, a process called study selection. Then, study quality assessment begins, which requires checking the quality of the finding. In other words, the researcher determines if these studies minimize the bias or not. In the data extraction step, the record of the information from the studies is constructed, including documenting the number of studies that have been checked, the number of participants in the studies, etc. Finally, organizing and summarizing the results from the studies is performed [13].

2.1.3 Documenting the Review

This is the final step of the systematic review. In this step, we document the results of the review.

2.2 Historical View of the Mechanical System [14]

In 1926, the term “intelligent machines” was used for the first time related to teaching purposes by Pressey, who built an instructional machine that had multiple choice questions with answers provided by teachers. This machine provided direct feedback to each question delivered and gave candies to the learner for each correct answer.

Pressey’s system was smart enough at that time, but it could not be considered intelligent because it presented preselected questions and answers. This machine included some modern education theories in its design, even though it was an inflexible machine that simply gave learners candies for each correct answer.

Around 1950, artificially intelligent machines had been established with the emergence of general-purpose computers. These machines had a binary system and electronic processor. Also, they had the ability to make logical decisions.

Turing, a British scientist, connected these computing systems and intelligence. He created the Turing test, which is a way to know a machine’s level of intelligence. The Turing test includes a specific question for both machines and humans. The test used conversations through communication links to distinguish between a human and a machine. This test has a very specific relationship with ITS. The main point that this test wanted to demonstrate is that is a rational person can distinguish between people and computers depending on the questions that were asked to both, and that for a computer to be successful, it has to communicate like a human. Some researchers tried to put knowledge in the ITS so that they could answer questions that students may ask.

Also, educational psychologists, in the mid-1950s, started adapting tutoring products to provide an effective learning experience for human beings. Since the 1970s, the ITS has been considered a good way to provide these adaptive tutoring products.

2.2.1 Computer Assisted Instruction (CAI)

Programmed instruction was used for the first time in the mid-1960s. Programmed instruction needs the designer to determine the input and the output. When learners answer any question incorrectly, an immediate correction will be done to the incorrect response and learners will be told about the accuracy of their solution before going to other questions. Programmed instruction was integrated into computer programs, which is known as computer assisted instruction (CAI). The programmed instruction and CAI have a lot of similarities, but the major difference between them is that CAI is managed on computers. In the first versions of the CAI, the materials of different courses had been managed and chosen step-by-step and were represented using frames. Also, the questions were very simple, and students were getting an immediate response if their answers were correct or not. Students could go to the next level regardless of the correctness of their answers. Experience showed that this kind of system is not effective because it provides the same material in the same sequence for all students, regardless of their learning abilities. This kind of system evolved to other types, such as the CAI evaluating a student's answer if it was correct or not in every single step of the education process so that it could lead a student to the best path. Students who answer a question correctly move to the next step; otherwise, there is a helping process that a student must take to solve a question correctly and move to the next step, as illustrated in Figure 2.1.

The CAI provides students with the material that they should learn and questions that they should solve. This method enables educators to gauge the students' level of knowledge gained from the material. Teachers provide these questions and their answers in advance so that the students' answers can be compared to the correct answer. If the student solves a problem correctly, a new question will be shown to him/her. Otherwise, the student enters a remediation process to review the material again and answer a simple problem so that he/she can come back again to the original problem that he/she could not solve.

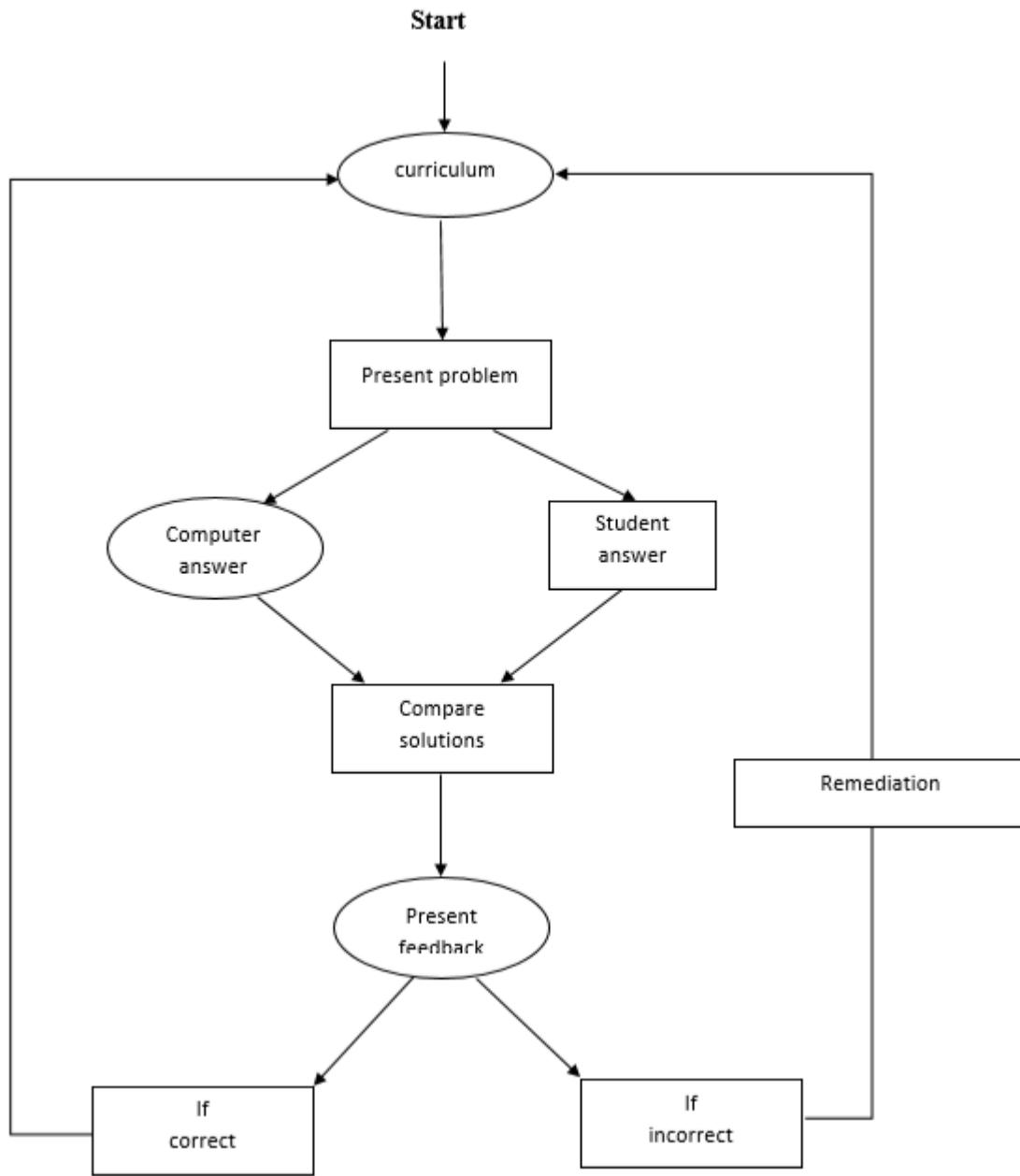


Figure 2.1 CIA chart

2.2.2 Intelligent Computer Assisted Instruction (ICAI)

There is not a significant difference between CAI and intelligent computer assisted instruction (ICAI), but it can be said that ICAI is a more sophisticated version of CAI. For example, if students have been asked to solve an addition problem between two numbers, only some of them may answer correctly. Let's suppose two students respond to a question

with their own answers but both of them answered incorrectly. The CAI does not know how to differentiate between these answers, so the CAI will take both students to the same remediation process. That means students who solve the problem incorrectly at the first time may do it again because they retake the same path again. The ICAI would respond by classifying these two answers so that it could correct each of them in different ways.

2.2.3 Artificial Intelligence and Education

In the 1970s, artificial intelligence (AI) was used in education to produce useful computers that could be used in learning. AI is the science of creating machines to do things which may be considered intelligent if done by people, and it leads to more understanding of knowledge. AI tutors work with students that have different abilities, allow collaboration, and integrate agents that are conscious of students' cognitive, affective, and social characteristics. These agents have the ability to recognize learning disabilities, communicate and replay information to the students as necessary. They lead and monitor students progress depending on the representation of both the content and public issues and bring about the chance of student's action. AI techniques can be called a self-improving tutor because the tutors can evaluate their own teaching [15].

2.3 Intelligent Tutoring Systems

2.3.1 Introduction to Intelligent Tutoring Systems

The main problems that faced CAI were that they did not provide rich feedback to students because the CAI was not designed to know what, how, and who it teaches. After many years, the feedback in the CAI has been improved, but it still insufficient because it lacks the knowledge of the domain that it teaches that humans have. As mentioned above, the CAI could not answer questions like how or why a task is done.

To overcome these problems, the CAI has been developed into ITS, which is a computer program that is designed to integrate AI in a way that it becomes a tutor that knows what, who, and how it teaches. ITS is different from CAI in these major ways:

1. ITS provide a clear delivery of knowledge for a specific domain.
2. ITS uses the student model, which is dynamically maintained and is used to create instruction.
3. The designer of ITS describes the knowledge and the assumption rules, but the program derives the sequence of teaching.
4. The detailed diagnostics of errors is provided by the ITS rather than simple drill and practice.
5. Students can post questions to an ITS.

AI is characterized by computers capable of doing things that may be considered intelligent if done by people. Similarly, ITS is a computer program that would be defined as good teaching because its design includes cognitive science, which is a combination of computer science, cognitive psychology, and educational research. ITS and ICAI are synonymous, but the acronym ITS is more commonly used now

ITS can serve the requirements of students. In other words, the ITS evaluates students' potential and manages their knowledge. Today, ITS is considered a system that can support a lot of students' needs [16]. Researchers have started focusing more on ITS for two reasons: the research needs and the practical needs. They want to know more about processes that contribute to the educational interaction. Because the ITS lies at the intersection of computer science, cognitive psychology, and educational research, it provides the researchers with a very good environment for many theories from cognitive

psychologists, AI scientists, and educational theorists. Furthermore, some results cannot be reached by using human tutors but can be reached by using ITS. The biggest reasons we use ITS are that it provides the one-to-one teaching environment, and it can address the needs of learners.

2.3.2 Architecture of Intelligent Tutoring System

ITS has many modules that help it to do its job. Figure 2.2 illustrates the ITS architecture.

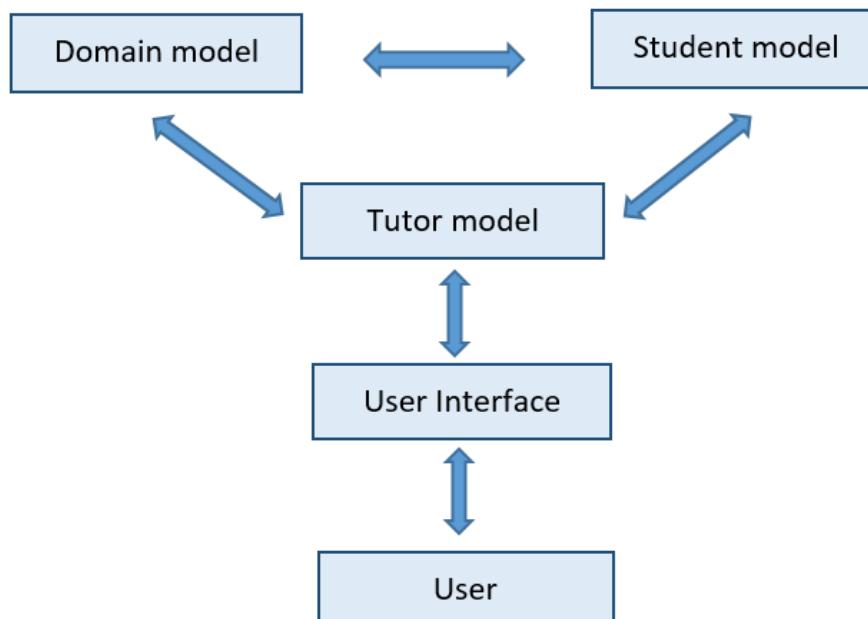


Figure 2.2. The ITS components

ITS has four different modules: Domain, Student, Teaching, and Learning Environment (or User Interface, sometimes called the Communication module) [9]. The ITS presents questions for students via the Learning Environment (user interface), which is the module in the ITS responsible for communicating with students. Students will enter their solution to this question through the same module. The Domain module has the knowledge about

the subject that the ITS teaches so that it has the correct answers to the questions. The Teaching module studies the information from the students, including the solution submitted by the students. This module depends on the information that the Domain module provides, so it can choose which solution is correct and which is not. In addition, the Teaching module uses the information obtained from the Student module, which is responsible for collecting the information about the students' behavior and features, so that it can choose which is the best feedback for any given student. Students get this feedback through the Learning Environment module. The Student module updates itself depending on the knowledge that has been collected about students from these questions.

2.4 The Domain Module

The Domain module represents the facts and rules of a specific domain to be conveyed to students. The Domain module has the knowledge of which things should be taught to students; it is also called the *knowledge of experts*. This module generates questions, explanations, answers, hints, and comments and provides standards to check students' performance. Domains vary in difficulty and structure, from simple (well defined) to complex, and from well-structured to ill-structured. They fall into three different categories:

1. Problem-solving domains, such as mathematics problems
2. Analytic and unverifiable domains, such as ethics and law
3. Design domains, such as architecture and music composition

For the simple and well-defined domains, the battery of training problems is presented using existing teaching strategies. However, there is no formal theory for verification for the complex and ill-structured domains.

2.4.1 Domain Module Approaches

The Domain module has three traditional approaches used to build it: constraint-based, rule-based, and dialogue-based [9].

2.4.1.1 Constraint-Based Module [17]

This approach includes many constraints about what is the correct solution, and it is not responsible for providing an explicit task model. The constraint-based module detects that a mistake has been made when students violates a constraint, and it helps students with the constraint that they violated. This approach does not suggest the next level that the students should do, which is considered one of the weaknesses of the constraint-based module. The constraint-based module examines just the final results. This module does not consider the path chosen by the user.

In this module, the set of constraints will be specified for the solutions. Each one of these constraints has a relevance condition and a satisfaction condition so that if the relevance condition is true, then the satisfaction condition is also true. In other words, if a student's solution follows the way defined by the relevance condition, it also follows the way defined by the satisfaction condition [18]. If any user does not follow the constraint, that means he/she does not know what this concept means and needs help. This means IF the relevance condition is satisfied by the problem state, THEN the satisfaction condition should also be satisfied by the problem state; otherwise, the student has committed an error [19]. For example, in the domain of algebra: if $C_r (x + y)/d$ is given as the answer to $x/d_1 + y/d_2$ $C_s d = d_1 = d_2$. If the solution provided by the student matches the relevance condition (C_r), it must be true that $d = d_1 = d_2$. If C_r is true, but C_s is violated (false), then

the student has made an error. A constraint is violated if and only if its relevance condition is true and the satisfaction condition is false [19].

The constraint-based module has been used for domains that do not focus on the methods students use to solve questions but focus on the validation of the solution itself. Making the constraint-based module work requires establishing a set of conditions that describe the best solution for the question. Building such sets of constraints is not an easy task. Sometimes, there are a lot of constraints that have to be built because there are a lot of solutions to the same questions. Another weakness of the constraint-based module is that the solution path to the violation of the constraint does not take into account the constraint-based module's tutors. In other words, a negative consequence of the constraint-based module is that the solution path the student has taken may be different from the best solution, so that the help that should be provided to student may be insufficient.

2.4.1.2 Rule-Based Module [9]

The basis of the cognitive tutors, which is another name of the rule-based module, is the adaptive control of the thought rational theory of cognition. The theory of cognition posits that there are two types of long-term memory: the declarative and the procedural. According to this theory, the human learning process passes through multiple phases. The first is the learning declarative knowledge phase, which is the overall knowledge about domains, such as facts or mathematical theories. Learners use this declarative knowledge to solve the questions of the domain. The other phase is called procedural knowledge, which is goal-oriented. This means that this phase works with specific procedures such as walking and talking and is represented by using the production rules.

In the rule-based module, there is a set of steps that the students have to follow to solve a problem. Also, this module provides immediate feedback for every step the user completes and signals an error by comparing the steps that students do with the solutions given by the expert. This process called Model Tracing. The rule-based models are built from cognitive task analysis, and each rule in the task models represents an action corresponding to a task.

The Model Tracing (MT) tutors follow the rule-based model. During teaching, the MT tutors do the following:

1. Suggest to the user which should be the next step taken.
2. Provide demonstrations.
3. Evaluate the understanding of the user in terms of the skills that the user has applied.
4. Infer user goals.

The MT tutor is used if the learning process is important and not simply checking answers for correctness.

2.4.1.3 Dialogue-Based Module [9]

This module holds conversations with students and therefore depends on speech, gestures, and facial expressions, in addition to texts and graphics, to deliver the material to users by agents. After receiving the questions, users must answer by typing in the English language. Users' knowledge can be improved depending on this conversational module.

For example,

STUFF (H, I, J, K, L, M, N, O)

DF1: H, I \longrightarrow J, K, L

FD2: J \longrightarrow M

FD3: $K \twoheadrightarrow N$

FD4: $L \twoheadrightarrow O$

The multi-turn dialogue between the agent and user to find the candidate key for the relation given in the example above is represented as:

- Agent: Enter the closure of HI. User: HI JKL
- Agent: There exists transitive dependency between FD2 and closure entered.
Modify the closure.
- User: HIJKLM.
- Agent: There exists transitive dependency between FD3 and closure entered.
Modify the closure.
- User: HIJKLMN.
- Agent: There exists transitive dependency between FD4 and closure entered.
Modify the closure.
- User: HIJKLMN.
- Agent: Is there any other FD to be processed? User: No.
- Agent: Does the closure contain all the attributes of the relation?
- User: Yes.
- Agent: So, the candidate key is HI.

2.5 Student Module [8]

The students' answers, behaviors, and actions are represented in the Student module. In other words, the knowledge and skills of students are represented in this module. ITS cannot exist without understanding of students' knowledge, so students' knowledge, behavior, and all other aspects that can affect students' performance should to

be included in this module. For many reasons, such as the communication channel (keyboard) is a restrictive communication channel, it is nearly impossible to build a student module that models all aspects of the student. On the other hand, sources such as voice and facial gestures could easily help human teachers to get information about students. Also, human tutors could easily know when students get motivated or fatigued.

The Student module's functions are classified into six types:

1. Corrective: to help eradicate bugs in the student's knowledge
2. Elaborative: to help correct 'incomplete' student knowledge
3. Strategic: to help initiate significant changes in the tutorial strategy other than the tactical decisions of 1 and 2 above
4. Diagnostic: to help diagnose bugs in the student's knowledge
5. Predictive: to help determine the student's likely response to tutorial actions
6. Evaluative: to help assess the student or the ITS

The Student module could also work as a source of data about students and as a student knowledge representation. As a source of information, the Student module collects information about students' behaviors, which can help to understand students' actions. Also, the Student module helps to reconstruct the knowledge representation in the Domain module. It can help evaluate each component of knowledge in the Domain module by comparing the domain knowledge with student knowledge.

2.5.1 Student Module Concepts

The Student module has several common concepts called overlay models, including the bug-libraries, which are the misconception models; the bandwidth, which is the

available information from the student; and the open user models, which are the tools that support students to evaluate their learning.

2.5.1.1 Overlay Models [20]

The student model usually uses an overlay model or subgroup of a Domain model to build it. This model can show the difference between the beginner and the expert thinker by determining student proficiency in each subject, what is the missing knowledge, and what are the educational components that need more work. This model is very simple to implement as soon as the domain knowledge has been counted, which means determining the steps that the expert does to solve a question. The domain knowledge provides weights for each step in the expert procedure, and it might be annotated by using rules. Students can get their knowledge through the open user model, which is provided by some overlay models. One of the limitations of this model is that learners usually have knowledge that is not included in the domain knowledge, and that leads to not representing it in the student model.

2.5.1.2 The Bug Libraries [21]

The bug-library is a predefined misconception and missing conception library. This library helps the system by finding bugs in this library to produce a student model that appropriates to students' performance. Gathering the bugs is one of the biggest challenges in constructing the bug-library. This library must be completed, otherwise if students have a bug that is not in the bug library, the student model should try to fit the student behavior with other bugs and this may make incorrect diagnosis to the student's misconceptions.

Some technique to assemble the bug library are:

1. Bugs can be collected from literature, particularly from the older works in the educational literature. Examples include bad habits or thoughts about arithmetic.
2. Bugs can be found by careful analysis of students' behaviors.
3. If there is a learning theory for the subject domain, it may be able to predict the bugs that students have.

2.5.1.3 Bandwidth [22]

The amount and quality of information that is available to the student model is described by the bandwidth. Bandwidth has the information about what students are doing or saying. There are three levels of bandwidth: approximate mental states bandwidth, final state bandwidth, and intermediate state bandwidth.

For the approximate mental states bandwidth, imagine that students are solving a question that has been given by themselves or by the ITS. If students spent a short amount of time, we can say that students went through steps of mental states. The maximum bandwidth that the ITS can reach would be a list of mental states that students go through to solve a problem. Machines cannot directly access the mental states of humans, so there is not an ITS that can reach the mental state bandwidth. Nevertheless, the highest bandwidth that is the approximate mental state can be reached by asking enough questions so that the ITS can collect information that approximates the students' mental states.

In other types of problem-solving, such as solving mathematics questions, students make many intermediate changes such as writing equations until they reach the final state when the question is solved. Sometimes, the intelligent tutoring system can access these

intermediate changes, and other times it can access only the final state, which is the answer. These levels of bandwidth are called the intermediate state and the final state.

2.5.1.4 The Open-User Model [20]

This model provides the students the right to manage and participate in the creation of the student model. This model has the beliefs of tutors about students. These beliefs could be student knowledge and many other features. The goals of this model are to improve the student model and to encourage students to take responsibility for their learning. Students like to compare their own information with other students or with what their teacher expects for the recent level of their course. There are a lot of questions that students should explore, such as:

1. What does the tutor know about me?
2. How did the tutor arrive at its conclusions about me?
3. How can I control the student model?

In this model, learners will examine their own student model. This examination is important to design the tutor and is important for many reasons:

1. Students have the right to access to and control their personal information.
2. The user model can be corrected by students.
3. There is an asymmetric relationship between student and tutor because of the student model.
4. There is a possibility of the student model to help reflective learning.

The more students examine their student model, the more they might lead to improved learning. However, students still do not know much information about themselves.

2.6 Teaching Module [8]

This module is the ITS component that is responsible for the design and control of the educational interactions with students. This module is connected to the student module in a way that it uses the information about students with its teaching goal to choose which educational activities should be presented, such as support, different tasks, explanations, hints, etc. In this module, it would be more effective to let students struggle before interrupting them. The students will get stuck or lost if left completely to themselves, but it would not be good for teachers to hinder students' sense of discovery. The Teaching module ranges from monitoring students' activities closely to the students' full control of their own activities. Between the system's full monitoring to the student's full monitoring, there is the mixed initiative system, which is shared control between the system and the students as they exchange problems and solutions. ITS generate learning goals and tasks and match these to learning outcomes before choosing the best intervention. Even though human tutors provide students with more flexible education than the software, the teaching basis supported by both human teachers and computer teachers looks similar. There are three teaching approaches implemented in the ITS:

1. Based on human teaching such as Apprenticeship training, Problem-solving/error handling, Tutorial dialogue, Collaborative learning.
2. Informed by learning theory such as Socratic learning, Cognitive learning theory, Constructivist theory, Situated learning, Social interaction.
3. Facilitated by technology such as Animated pedagogical agents, Virtual reality.
4. Teaching module has many aspects that are used to help students improve their knowledge, and one of these aspects is feedback [23].

2.6.1 Feedback

Feedback provides students with very good information that can help them solve problems, understand a misconception, etc. Depending on the feedback, ITS can know the gap between a student's current performance and the expected level that student should have reached so that it can reduce this gap by motivating higher levels of efforts. Students' ability of understanding and solving problems can be improved by using motivation, and feedback is a great motivator for students. Effective feedback has many advantages. Some feedback activities, such as when feedback provides students with more details about the way to improve their answers rather than just telling them that their solution is correct or not, are better than others. Also, feedback that concentrates on the features of the questions ("Did you try to add 97 to 56?") helps to get higher learning and success. Students with high performance levels should get delayed feedback, specifically for complex tasks, whereas students with low performance levels should get immediate feedback.

There are two kinds of feedback: negative and positive. Negative feedback is provided to students when they make mistakes so that this feedback can help students correct their mistakes and prevent them from making the same mistakes again in the future. On the other hand, positive feedback is provided to students when they solve the questions correctly. Students' knowledge can get reinforced when they receive this feedback. Also, students' new knowledge can successfully be integrated by this feedback if the correct answer to a problem is provided by a random step [24].

2.7 Communication Module [23]

The Communication module is the part of the ITS that is responsible for the communication between students and the tutors. Human responses such as graphics,

diagrams, and essays can be accepted by computer tutors. ITS, such as Atlas and AutoTutor, mimic many strategies that humans use to communicate, such as compose spoken or textual explanations. The computer interface has an important effect on the learning results because it integrates the other tutors' features so that the ITS has a rich design for its interface; otherwise, a poor interface can affect the whole learning process in a negative way. The ITS's interface has to understand the effective features of students, such as motivation, besides the students' responses such as text and speech.

The efficiency of the computer communicative tactics seems better than the same tactics that human use. For example, training police officers to recognize people who have mental issues requires many hours, many trainers, complex scheduling, and many other things. A sophisticated computer can be built once and it can be reused many times for training with little additional cost.

2.8 Examples of Intelligent Tutoring Systems

2.8.1 WhaleWatch [25]

WhaleWatch is an ITS that is used to help 5th and 6th grade students learn mathematics principles. This ITS starts by building a profile about what students already know about mathematics and how fast they can improve by giving students several baseline arithmetic problems. WhaleWatch starts giving students simple fraction problems that need more thinking to solve once students become proficient with numbers. To increase interaction between students and this ITS, WhaleWatch displays pictures of endangered species and starts asking mathematical questions about these pictures, as shown in Figure 2.3. An example question is: If a group of whales traveled 13 miles and other group traveled 2 miles, how much more did the first group travel more than the other group?

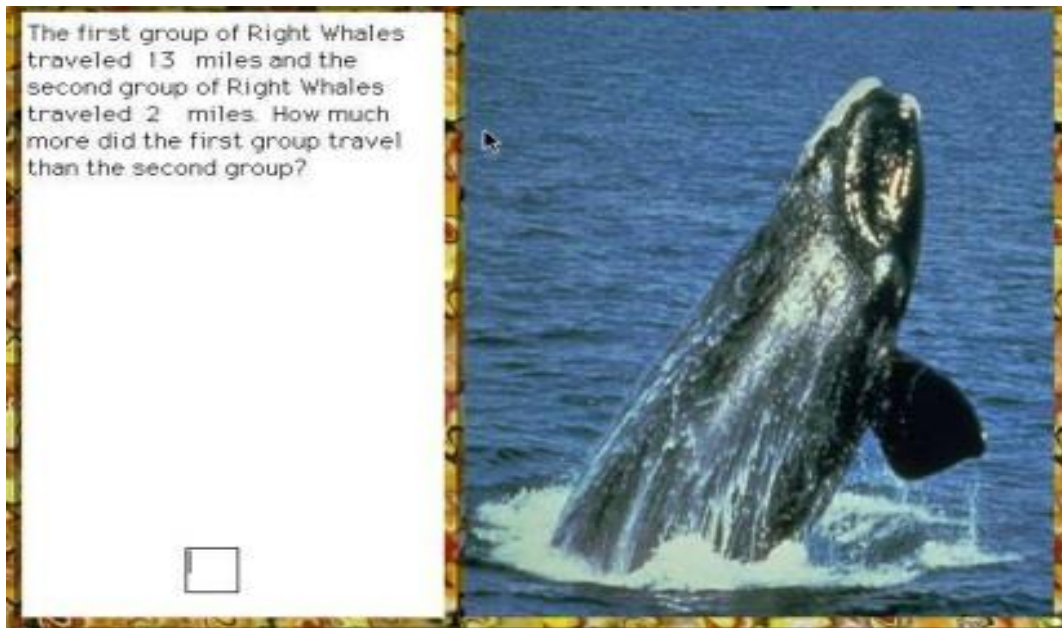


Figure 2.3 WhaleWatch

WhaleWatch provides students with hints and guidance when students make mistakes. When students correctly answer questions, this ITS responds with positive auditory responses; otherwise it responds with an encouragement message to try solving the question. WhaleWatch uses multimedia wisely to involve students by using animation concepts based on what is used by classroom teachers. WhaleWatch has been tested on a lot of students. The first test tried to know if this ITS has a positive effect on girls' self-confidence. The results showed that girls' self-confidence increased and it became the same level as boys, whereas boys' self-confidence stayed the same. The second test examined whether girls' confidence increased because of the help of the tutor or not. They split the students into two groups and gave half of the students the help that this ITS provides and the other half no help from this ITS. Even though boys did not get tutor help, their confidence increased. When they got the tutor help, their confidence decreased. This happened because boys felt constrained by the amount of time taken by hinting. This ITS

suggests that we must concentrate more on the way of providing hints for students in a way that presents these hints more attractively and helpfully.

2.8.2 Pump Algebra Tutor (PAT) [23]

This ITS is designed for 12 to 15-year-old students to teach them algebra. To express relationships and solve problems, students use many tools such as tables, graphs, spreadsheets, and symbolic calculators, as shown in Figure 2.4.

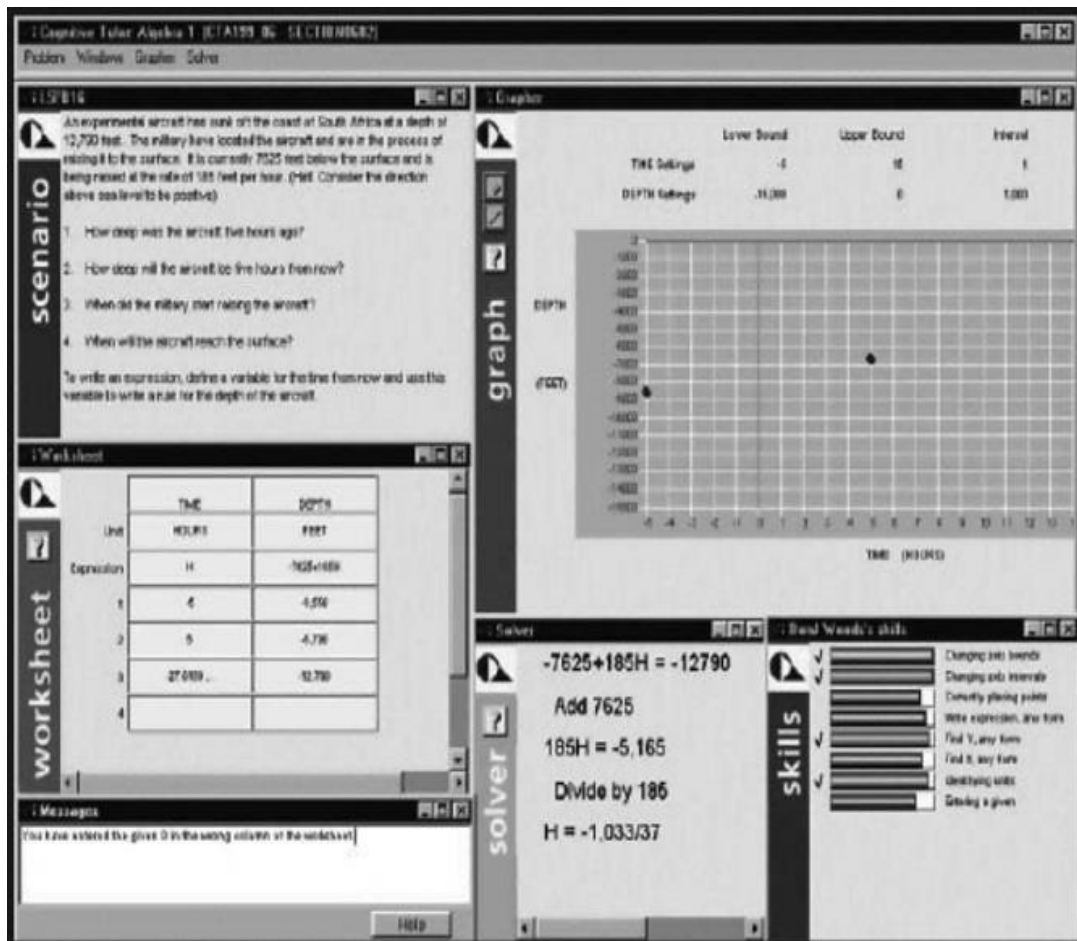


Figure 2.4 PAT tutor

This ITS has the following aspects [23]:

1. Problem scenario. The problem scenario poses multiple questions.

2. Worksheet. As students progress through the curriculum, they generalize specific instances into algebraic formulas. Students complete the worksheet by recording answers to questions posed in the problem scenario.
3. Just-in-time help messages. Students receive immediate feedback after errors.
4. Graph. Students set boundaries and intervals, labeled axes, and plot graph points.
5. Skills. The cognitive tutor dynamically assesses and tracks each student's progress and level of understanding on specific mathematical skills.

The goal of this ITS is to help students use algebra successfully to solve problems. Pump Algebra Tutor provides knowledge and practice with methods such as problem-solving, algebraic notation, algorithms, and geometric representations. To solve problems, students represent information in many ways such as text, graphs, and tables. Also, to examine a given situation and answer questions, students use the represented information. PAT has been tested in many high schools. It compared the results that students got by using PAT to those who did not use it and used the traditional algebra course. The results showed that students who used PAT scored 15% to 25% better on skills, and obtained 50% to 100% enhancement on problem-solving. PAT provides students with timely feedback. PAT traced the students' performance when they solve problems and provides students with feedback when they make mistakes. This feedback is provided by showing incorrect points in the graph tool as gray rather than black. The learning process time can reach three times longer if feedback is delayed rather than if it is given immediately. The feedback could also be a message to show students what was wrong with their answers. Depending on the students' current concentrated action, the students' solution, and the knowledge of

interdependencies between problem-solving activities, PAT can identify the next activity that the student should learn.

2.8.3 AutoTutor [26]

AutoTutor is an ITS that simulates the discourse patterns and pedagogical strategies of a typical human tutor. This ITS has been designed to help college students in learning the basics of hardware, operating systems, and the Internet. AutoTutor provides problems and questions from a course script, tries to know learner contributions that are entered the system by keyboard, defines negotiation changes that are sensitive to the contributions of the learner (e.g., short feedback and hints), and delivers the dialog changes with a talking head.

According to [26], “AutoTutor has seven modules: a curriculum script, language extraction, speech act classification, latent semantic analysis, topic selection, dialog move generation, and a talking head.”

AutoTutor provides a multi turn dialogue between itself and a student. In other words, this ITS and students engage in a question-answer conversation for 20 to 30 minutes to answer a single question. For example [26],

1. AUTOTUTOR: When you turn on the computer, how is the operating system first activated and loaded into RAM?
2. STUDENT: When the computer is turned on a file is automatically booted up.
3. AUTOTUTOR: Anything else?
4. STUDENT: This file contains the operating system.
5. AUTOTUTOR: What else?
6. STUDENT: The operating system is then read into RAM and activated.

7. AUTOTUTOR: Right. The CPU executes instructions in ROM, which help the operating system to start.

8. STUDENT: After being read to ROM the OS is activated.

9. AUTOTUTOR: Right. Let's review what we've just gone over. The operating system must first be stored on the hard disk. When you turn on the computer, the CPU executes instructions stored in ROM. These instructions help boot the operating system. The operating system is then loaded from the hard disk into RAM.

Instead of providing students with a large amount of information, AutoTutor is a discourse prosthesis that attempts to get the student to do the talking and explores what the student knows. Also, AutoTutor summarizes the conversation that happens between itself and students as in step 9 above.

2.8.4 Cognitive Tutor Algebra I Program [27]

Cognitive Tutor Algebra I program is an ITS that has been designed to provide students with an opportunity to learn Algebra I in both classroom and computer lab settings. This software is used to understand the methods that students may use to solve problems and to offer individualized help to the students. The computer program adapts to the student by selecting problems according to the student's requirements. Also, Cognitive Tutor Algebra I program enhances students' understanding of mathematics and increases students' involvement in the learning process. This ITS is used in several schools. To prove the effectiveness of this ITS, the Moore Independent School District in Moore, Oklahoma did a study on this program. They assigned students to use this ITS and other students to use a different program. Students who used the Cognitive Tutor Algebra I program scored

higher grades and demonstrated more positive attitudes toward math than the other group [28].

CHAPTER 3: METHODOLOGY

This chapter explains the protocol that has been used in this thesis to collect and analyze the papers that discuss the effects of ITS.

3.1 Background

As mentioned in Section 1.2 of this thesis, traditional education has many problems linked to the use of a teacher who maintains control over the students' entire educational experience. This system led to many problems, such as the difficulty for students with varying levels of preparation to learn effectively within a system that does not account for differences. As we know, not all students have the same brain or capacity for learning, which can cause them frustration when they're unable to learn in traditional classrooms. They need an education system that teaches to their ability.

These reasons and many other reasons led me to think about ways to improve this system. An ideal solution would be to provide one teacher for every student because one-to-one teaching has a high degree of success. Teachers can know their students' ability and what they need if they teach them on a one-on-one basis. However, this solution is very expensive and nearly impossible.

For these reasons, Woolf (1988) suggested that using ITS may help to solve this problem [4]. After reading that suggestion, I started looking for the effects of ITS on the education system in general. As a result of my search, I found thousands and thousands of academic papers discussing ITS. Because of this huge number of papers, using the systematic review to construct an objective summary of them is the best way to provide the evidence of the effectiveness of the ITS. In contrast to a traditional review, systematic review provides unbiased and rigorous review.

3.2 The Research Questions

The research question addressed in this thesis is: Does ITS improve students' learning abilities more than the traditional learning approach?

3.3 Search Process

The goal for any systematic review is to find studies that can answer the research questions. To do this, I followed the strategy depicted in Figure 3.1. The results I obtained from the search were strongly affected by the databases and keywords I chose.

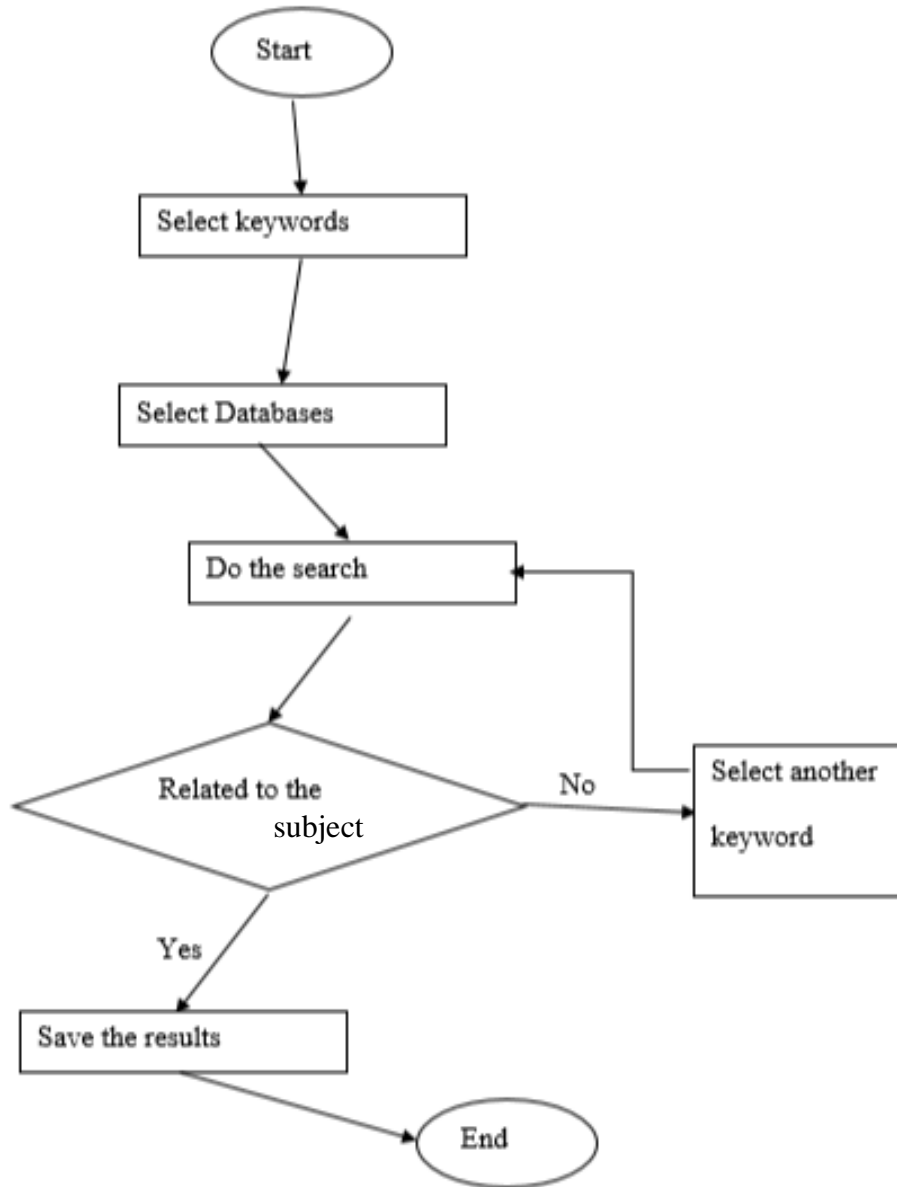


Figure 3.1. The search strategy

The search was conducted for the ITS studies that took place since 1990. I used the following bibliographic databases:

1. IEEE (Institute of Electrical and Electronics Engineers)
2. ERIC (Education Resource Information Center)
3. PsycINFO (Psychology Information)
4. Science Citation Index

5. Social Science Citation
6. Science Direct
7. Applied Science
8. Google Scholar

I used the following keywords when I searched for the studies:

1. Intelligent tutoring system.
2. Cognitive tutor.
3. Intelligent agent system.
4. Intelligent coaching.

This initial search returned 32,144 titles. After reading the abstracts for all of them, just 210 titles remained. Then, the inclusion and exclusion criteria was applied to the remaining articles and 45 studies and articles were identified.

3.4 Study Selection Criteria

Study selection criteria were used to determine which studies are included in or excluded from this systematic review.

3.4.1 Inclusion and Exclusion Criteria

For studies to be included in this systematic review, the following criteria had to be met:

1. The studies should be about the effects of ITS on learning. Any other studies were excluded.
2. Studies which have ITS experiments on learning were included. Any other studies that concentrate on other domains, such as the military, were excluded.

3. Studies that compare the effects of the ITS on people who use ITS with those who do not were included. Others were excluded.
4. Studies that were published from 1990 until 2017 and published in English were included. The year 1990 was chosen as the starting year because many studies on the effectiveness of ITS began at that time.
5. Studies that can be accessed online or on the Wright State University Library website were included.
6. Studies that have sufficient results and statistics were included.

3.5 Study Selection Procedures

This protocol describes how the selection criteria were applied to the studies (e.g., how many assessors evaluated each prospective primary study and how disagreements among assessors were resolved). In this thesis, I worked on evaluating each study so that I chose the selected studies based on the criteria that the predefined protocol has set. When uncertain about a study, I requested my supervisors, Dr. Rizki and Dr. Raymer, for clarification. The rejected studies were also checked by me, and checked two times to be sure they were not related to what this thesis is trying to focus on.

3.6 Study Quality Assessment Checklists and Procedures

For this thesis, the systematic review of the effects of the ITS was evaluated using the criteria of the Center for Reviews and Dissemination (CDR) Database of Abstracts of Reviews of Effects (DARE) of the York University[13]. For a study to be included, it had to meet at all four of the following criteria:

1. Are inclusion/exclusion criteria described?
2. Is the search adequate, and covered all relevant studies?

3. Is the quality of the included studies assessed?
4. Are sufficient details about the individual included studies presented?

These questions were given a score as follows:

- Question 1: 1 point if the inclusion criteria have been met in the study, 0.5 point if the inclusion criteria have been met partially, and 0 if the inclusion criteria have not been met.
- Question 2: 1 point if the researcher has searched more than four digital libraries, 0.5 point if the researcher searched two or less than four digital libraries, and 0 point if the researcher searched less than two digital libraries.
- Question 3: 1 point if the researcher has defined criteria for the study's quality, 0.5 point if the researcher has addressed quality issues in his/her research questions, and 0 points if the researcher does not indicate any explicit quality criteria.
- Question 4: 1 point if the results of the study have been presented, 0.5 point if just a summary of the study has been presented, and 0 point if the result has not been presented.

3.7 Data Collection

Once the studies had been identified in the systematic review, data collection began. As mentioned in Section 3.3, the data of this thesis were collected through a manual search process. The search was conducted for ITS studies that have taken place since 1990. After collecting these data, I started extracting the following from each source:

1. General information such as:

- Authors, title, source and year of publication.
- Publication type such as journal article, book chapter, etc.

2. Study characteristics such as:

- Participant characteristics such as demographics, sample size, sex, ages, etc.
- Information that I need for quality assessment.

3. Inclusion and exclusion criteria of these studies.

4. Outcome of these studies such as:

- Data such as mean, standard deviation, number of participants in each group, etc.

5. Other information available and relevant to the studies such as graphs, charts, etc.

6. Summary of the studies.

7. Any required comments.

3.8 Data Synthesis

Data synthesis involves collecting and summarizing the results of the selected primary studies [13]. The data synthesis is already specified in the review protocol. The extracted data was descriptively and quantitatively synthesized in such a way to answer the thesis question, which is defined in the review protocol.

In the descriptive synthesis, the information extracted from the studies is related to intervention, population context, outcome, etc. This extracted information was tabulated in a way that answers the thesis question [13]. In the quantitative synthesis, I used a paired t-test and a one-way ANOVA test to represent the results.

3.9 Reporting the review (Dissemination)

This is the final phase of the review protocol. In this phase, the results of the studies are reported. After extracting the relevant data, the collected data were synthesized. The results of this systematic review are presented in the next chapter.

CHAPTER 4: RESULTS

This chapter discusses the results obtained from all included studies. There were 12,105 students who participated in these studies and whose experiences are used in this thesis. This number of students is distributed as follows: 1093 computer science students, 2666 physics students, 7147 mathematics students, 186 physiology students, 76 accounting students, and 937 reading students. There are also a few papers that this thesis did not use in the tests because they lack results, but they have been used as evidence of students' acceptance or rejection of ITS. Analysis of the extracted data of these papers showed that most them support the claim of the effectiveness of the ITS on students, but there are also some papers that showed that students did not improve when they used the ITS.

4.1 Results (Mean and Standard Error of the Mean)

In order to analyze the extracted data from the 45 papers, I used a paired t-test and one-way ANOVA test. The t-test compares the mean scores of the two groups (i.e., the ITS group and the control group), whereas the one-way ANOVA test identifies the difference between these two groups. Before attempting to find results from these two tests, I had to find the mean, the standard deviation, and the standard error of the mean for each major and for all papers as one because they are considered the input for the t-test and the one-way ANOVA test. The majors for which I found the mean and standard deviations are Computer Science, Physics, Mathematics, Physiology, Accounting, and Reading. There are also other majors, such as Logic and Economics, for which I did not

find the standard deviation because of lack of information. The mean and the standard error of the mean for the computed majors are illustrated in Figures 4.1-4.7.

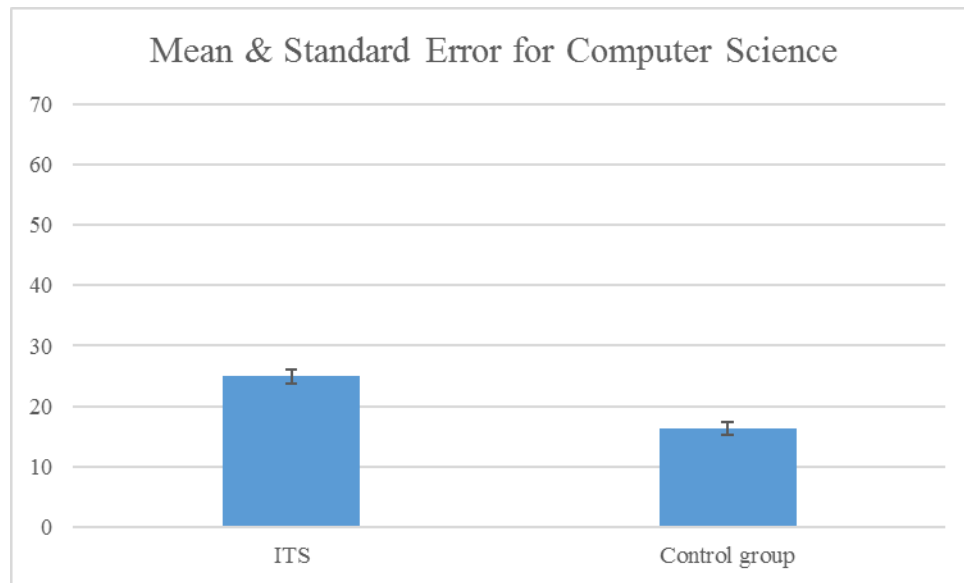


Figure 4.1. Computer Science mean and standard error of the mean for ITS and control group

In Figure 4.1, the mean gain score value of students who use ITS for their learning in the computer science major is 24.9, whereas the mean gain score value for students who did not use ITS is 16.2. In other words, students who used the ITS enhanced their learning more than students who did not use it. To prove this point, the results of the t-test and one-way ANOVA test are illustrated in Tables 1 and 2, respectively.

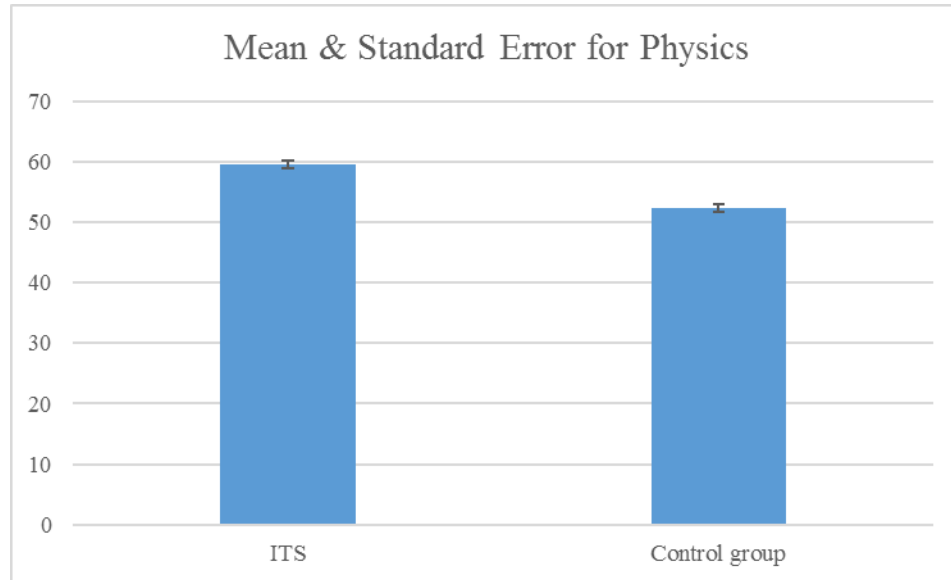


Figure 4.2. Physics mean and standard error of the mean for ITS and control group

In Figure 4.2, the mean gain score value of students who did not use ITS for their learning in the physics major is 52.4, whereas the mean gain score value for students who used ITS is 59.5. This means that students who used the ITS in their learning improved more than students who did not use it. To prove this point, the results of the t-test and one-way ANOVA test are illustrated in Tables 1 and 2, respectively.

In Figure 4.3, the mean gain score value of students who used ITS for their learning in the Mathematics major is 43.1, whereas the mean gain score value for students who did not use ITS is 33.3. In other words, students who used the ITS enhanced their learning much more than students who did not use it. To prove this point, the results of the t-test and one-way ANOVA test are illustrated in Tables 1 and 2, respectively.

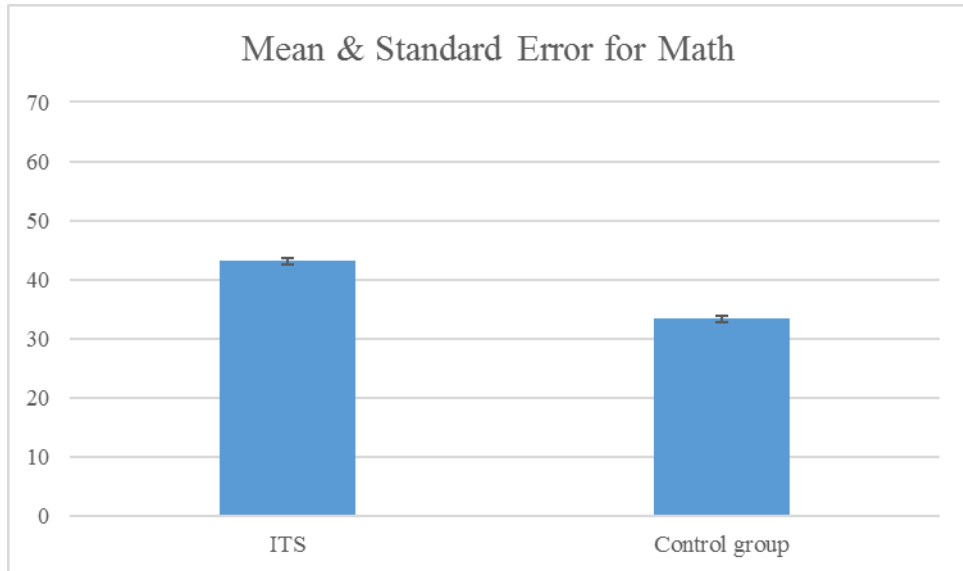


Figure 4.3. Mathematics mean and standard error of the mean for ITS and control group.

In Figure 4.4, the mean gain score value of students who use ITS for their learning in the physiology major is 18.2 while the mean gain score value for students who did not use ITS is 5.5. That means that students who used the ITS in their learning progressed more than students who did not use it. To prove this point, the results of the t-test and one-way ANOVA test are illustrated in Tables 1 and 2, respectively.

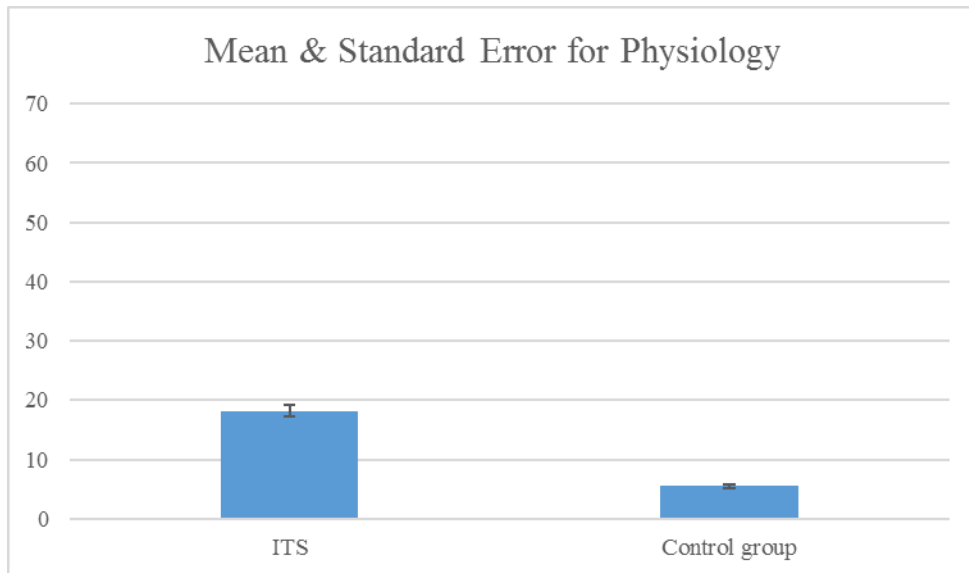


Figure 4.4 Physiology mean and standard error of the mean for ITS and control group.

In Figure 4.5, the mean gain score value of students who did not use ITS for their learning of the accounting major is 24.3, whereas the mean gain score value for students who used ITS is 32.0. This means that students who used the ITS in their learning improved more than students who did not use it. To prove this point, the results of the t-test and one-way ANOVA test are illustrated in Tables 1 and 2, respectively.

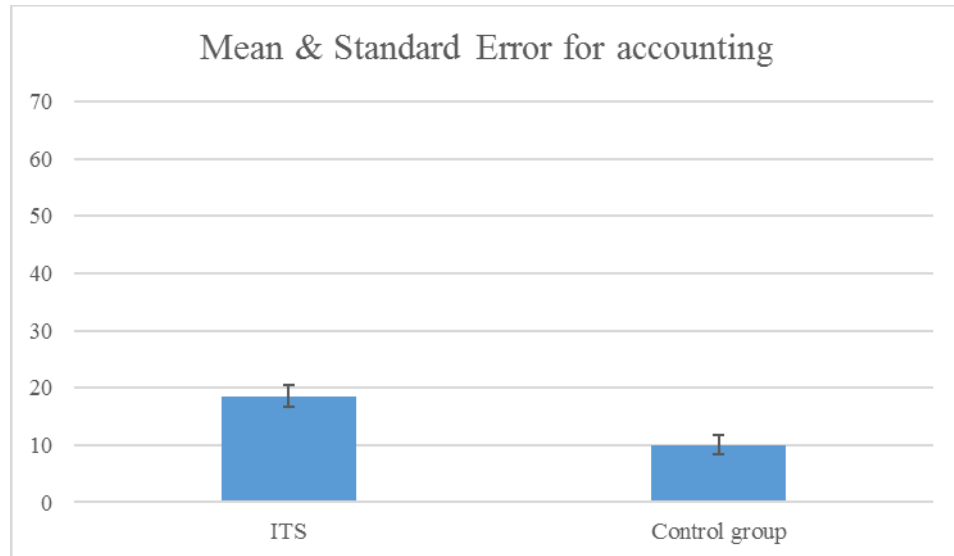


Figure 4.5. Accounting mean and standard error of the mean for ITS and control group.

In Figure 4.6, the mean gain score value of students who used ITS for their learning in the reading major is 11.7 while the mean gain score value for students who did not use ITS is 5.7. In other words, students who used the ITS enhanced their learning much more than students who did not use it. To prove this point, the results of the t-test and one-way ANOVA test are illustrated in Tables 1 and 2, respectively.

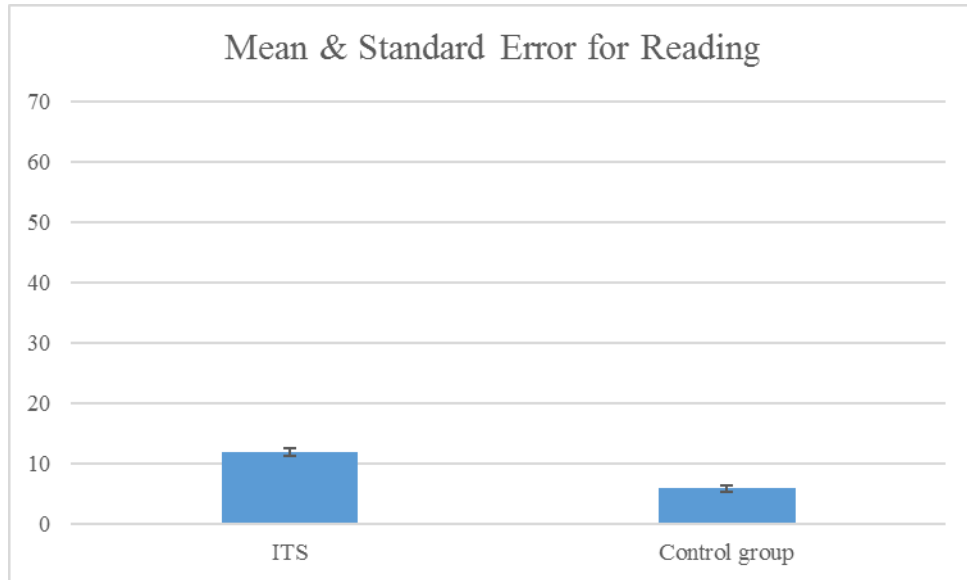


Figure 4.6 Reading mean and standard error of the mean for ITS and control group

After finding the mean, standard deviation, and standard error of the mean for each major, the mean, the standard deviation, and standard error of the mean for all studies as one was found; the result of that is illustrated in Figure 4.7.

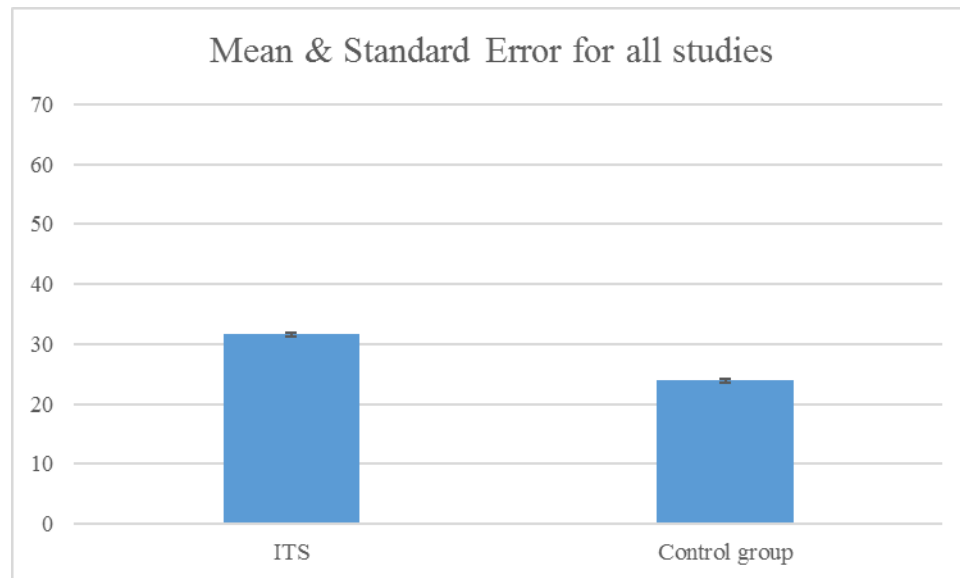


Figure 4.7. All studies' mean and standard error of the mean for ITS and control group.

In figure 4.7, the mean gain score value of students who used ITS for their learning for all majors is 31.6, whereas the mean gain score value for students who did not use ITS

is 23.9. That means that students who used the ITS in their learning progressed more than students who did not use it. To prove this point, the results of the t-test and one-way ANOVA test are illustrated in Tables 1 and 2, respectively.

4.2 Results (t-test and one-way ANOVA test)

To analyze these results, first I conducted a t-test and a one-way ANOVA test.

Table 1 presents the obtained results of the t-test.

Table 1. *A Comparative Overview of Students' Mean Scores and Their t-test Results*

	ITS group	Control group	Statistical significance
All studies			
Mean (SD)	31.6(29.2)	23.9(28.2)	P<0.0001
Computer science			
Mean (SD)	24.9(26.0)	16.2(25.6)	P<0.0001
Physics			
Mean (SD)	59.5(24.3)	52.401(23.7)	P<0.0001
Mathematics			
Mean (SD)	43.1(34.9)	33.3(32.9)	P<0.0001
Physiology			
Mean (SD)	18.2(10.3)	5.5(3.5)	P<0.0001
Accounting			
Mean (SD)	18.5(12.0)	10.0(10.0)	P=0.0013
Reading			
Mean (SD)	11.7(13.3)	5.775(11.3)	P<0.0001

Table 1 shows that the ITS groups (the groups who learned using ITS) for all majors of study have mean gain scores higher than the other groups who did not use the ITS in their learning, and they showed a significant improvement in the t-test where their P values were less than 0.0001. In all studies, considered as one, the mean gain scores value of the

ITS group was 31.6, whereas the mean gain scores value of the control group was 23.905, and the scores showed significant improvement ($P < 0.0001$). These results proved that the ITS has a beneficial effect on the students' learning and brings a huge improvement in their performance over time.

The one-way ANOVA statistical model was used to identify differences between the ITS group and the control group. This model was chosen because it is the most appropriate method of statistical analysis of experiments involving more than two groups [29]. Table 2 shows the ANOVA results for the ITS and control groups.

Table 2. *Statistical Analysis of the Mean Scores for ITS and Control Group*

	ITS group	Control group	F-value	P-value
All studies Mean (SD)	31.6(29.2)	23.9 (28.2)	220.1	0.000
Computer science Mean (SD)	24.9 (26.0)	16.2 (25.6)	30.7	0.000
Physics Mean (SD)	59.5 (24.3)	52.4 (23.7)	58.0	0.000
Mathematics Mean (SD)	43.1 (34.9)	33.3 (32.9)	147.1	0.000
Physiology Mean (SD)	18.2(10.3)	5.5(3.5)	125.9	0.000
Accounting Mean (SD)	18.5(12.0)	10.0(10.0)	11.1	0.001
Reading Mean (SD)	11.7(13.3)	5.7(11.3)	55.4	0.000

Notes. F-value is the measurement of distance between individual distributions; the P-value is the probability of obtaining a result at least as extreme as a given data point.

Table 2 showed that there is a significant improvement in the ANOVA test where their P values were less than 0.0001.

CHAPTER 5: LATENT DIRICHLET ALLOCATION

5.1 Latent Dirichlet Allocation

Latent Dirichlet Allocation (LDA) is a generative probabilistic model of a corpus. The basic idea behind LDA is that documents are represented as random mixtures over hidden topics, where each topic is characterized by a distribution over words [30]. In other words, LDA is a way of discovering topics in text documents so that it used in this thesis to discover what are the common topics associated with ITS papers and what are the common words. LDA is considered an illustration of a topic model and was presented for the first time in 2003 as a graphical model by three scientists, David Blei, Andrew Ng, and Michael I. Jordan.

5.1.1 Topics

In the LDA, each document can be seen as a combination of many topics, where every single document has a set of topics that are allocated to it by the LDA. For example, the topics of the LDA model might have topics, such as *food-related* and *animal-related*. Each topic has its probabilities of generating many words that are related to it, such as *apple* and *banana*, which can be classified by the LDA as food-related, and words such as *dogs* and *cats*, which can be classified by LDA as animal-related. Each document is characterized by a set of topics.

5.1.2 Model

LDA uses a plate notation, which is a method of representing variables that repeat in a graphical model. This means that instead of drawing each repeated variable

individually, a plate or rectangle is used to group variables into a sub-graph that repeat together, and a number is drawn on the plate to represent the number of repetitions of the subgraph in the plate [30]. See Figure 5.1 for an example.

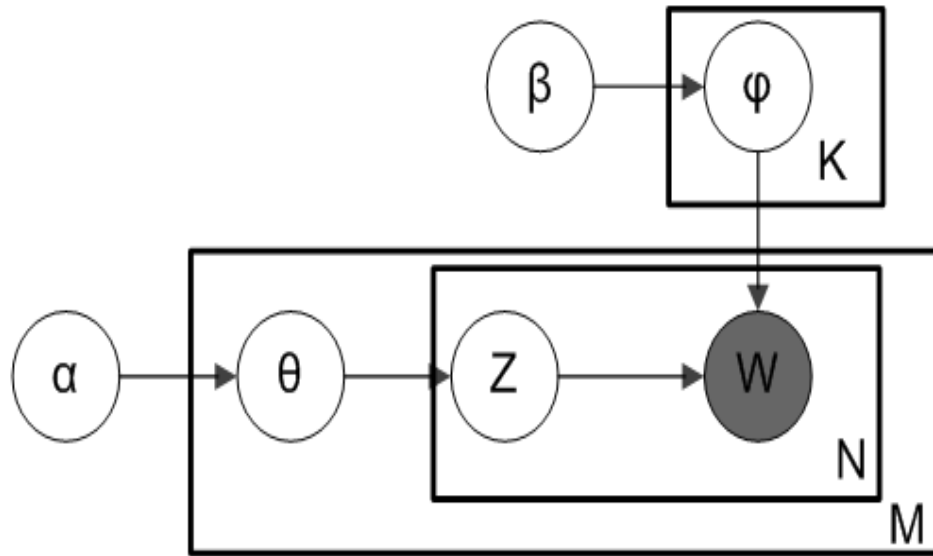


Figure 5.1 LDA plate notation

As illustrated in Figure 5.1, the boxes, which are the plates, represent the replicates. The inner box represents the topics and words of the documents, whereas the outer box is representing the chosen documents. The M box represents the number of documents, and the N box represents the word's number of each document. The following is the meaning of each symbol of the LDA figure:

- α is the parameter of the Dirichlet prior on the per-document topic distributions. A high Alpha indicates that each document is likely to contain a mixture of most of the topics and not just one or two, whereas a low Alpha indicates that each document will be likely to contain a few of the topics.

- β is the parameter of the Dirichlet prior on the per-topic word distribution. A high Beta indicates that each topic is likely to contain a mixture of most of the words, whereas a low Beta indicates that each topic is likely to contain a mixture of just a few words.
- θ_M is the topic distribution for document M.
- φ_K is the word distribution for topic K
- Z_{MN} is the topic for the N-th word in document M
- W_{MN} is the specific word.

5.1.3 Generative Process

According to LDA, if we want to create a new article, the first thing we have to do is to determine the number of words in the document. The second step is to choose a topic mixture for the document over a fixed set of topics, for example: 20% topic A, 30% topic B, and 50% topic C. The third step is to generate the words in the document by first picking a topic based on the document multinomial distribution above, and that is 20% topic A, 30% topic B, and 50% topic C. Next, one would pick a word based on the topics' multinomial distribution of their own distribution, which would be iterated until the number of words specified is reached. For example, if we have a group of documents, we assume that all these documents can be characterized by three topics, such as animals, cooking, and politics. Each of these topics can be described by the following words:

- Animals can be described by *dog, chicken, cat, nature, and zoo.*
- Cooking can be described by *oven, food, restaurant, plates, taste, and delicious.*
- Politics can be described by *Republican, Democrat, and Congress.*

If we want to generate a new document in LDA that is 80% about animals and 20% about cooking, we choose the words and then we choose the topic so that if the new document has 1000 words, 800 words should be from animals and 200 words from cooking. Syntax is not a consideration, so we will never read the new document, but we can understand that this document is about cooking and animals and not about politics.

5.1.4 Working Backwards

Suppose we have a corpus of documents and we want LDA to learn the topic representation of K topics in each document and the word distribution of each topic. LDA backtracks from the document level to identify topics that are likely to have generated the corpus.

To sum up, LDA takes many documents and assumes that the words in each document are related. It then tries to figure out the recipe for how each document could have been created. We just need to tell the model how many topics to construct and it uses that recipe to generate topics and words over the corpus. Based on that, we can identify similar documents within the corpus.

5.2 KNIME Analytics

Konstanz Information Miner (KNIME), which is illustrated in Figure 5.2, is an integration, reporting, and data analytics platform program. The idea behind KNIME is to create a program that can integrate different data for analysis and processing in a visual way. KNIME mixes many parts of data mining and machine learning via its modular concept. KNIME has its own Graphical User Interface (GUI), which allows it to connect many components together for data analysis and processing. This program has the ability to perform LDA that it received as input. This program was developed by a team of

software engineers in 2004 at University of Konstanz. In 2006, the first version of KNIME was released and used.

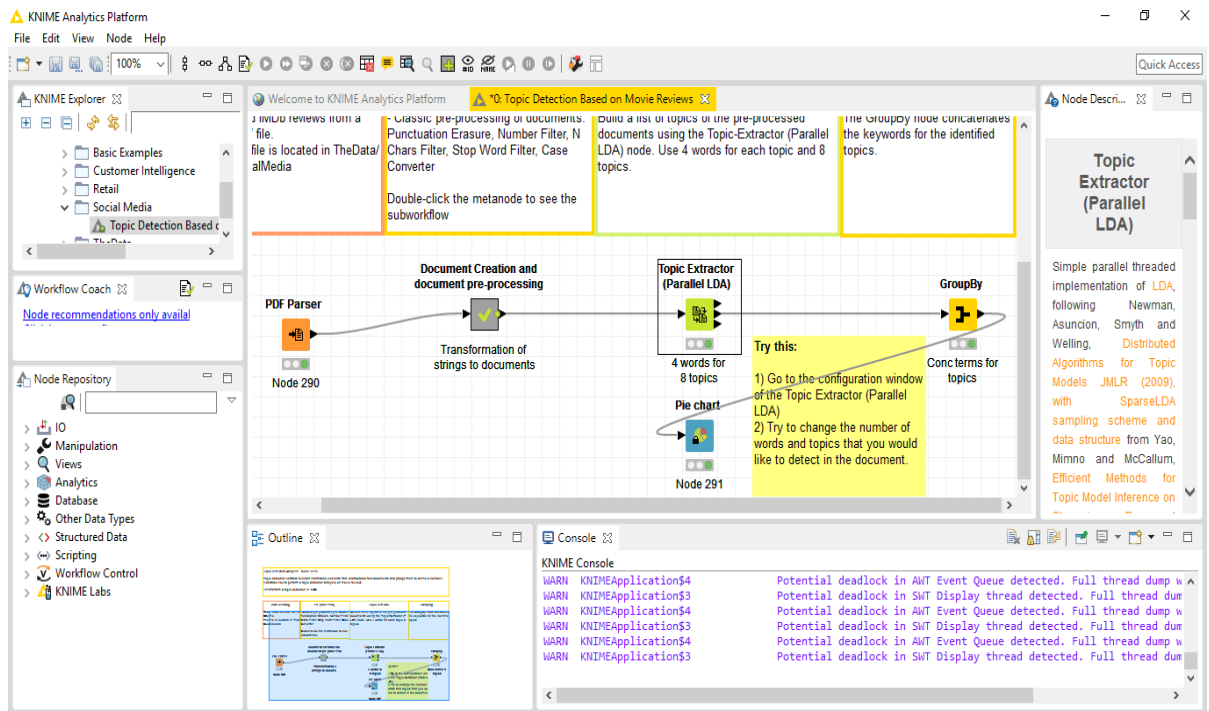


Figure 5.2 KNIME program

5.2.1 KNIME Components

KNIME is made up of many components found in the Node Repository that can be used analyze and process data. There are four components, illustrated in Figure 5.3, that have been used in this analysis: PDF Parser, Document creation and Document preprocessing, Topic extractor (parallel LDA), and Group by.

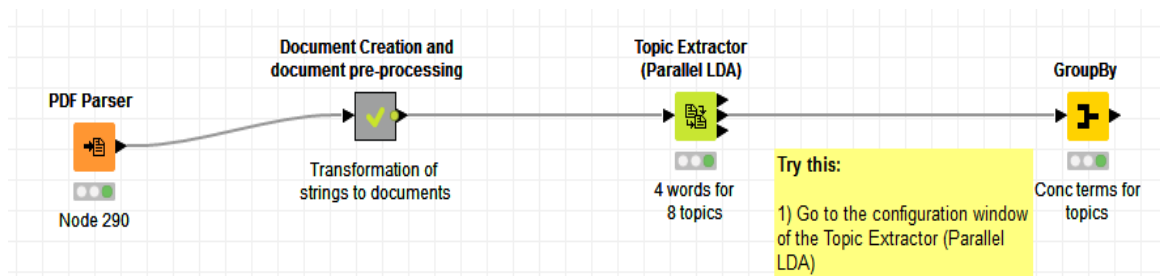


Figure 5.3. KNIME components that are used in this thesis.

The PDF Parser node allows us to read PDF documents and create a document for each file. The document's title and authors will be extracted from the PDF's meta data. The full text of the PDF is extracted; the structure of the PDF is not taken into account. For text extraction, the PDFBox library is used [31].

The Document Creation and Document Preprocessing node is responsible for: Punctuation Erasure, which erases the punctuation characters of document terms; Number Filter, which filters document terms consisting of digits; N Chars Filter, which filters document terms with fewer than N characters; Stop Word Filter, which filters document terms contained in the stop word list; and Case Converter, which converts document terms to lower or upper case [31].

The Topic Extractor (i.e., parallel LDA) is a simple parallel-threaded implementation of LDA. It has the following components: Document column, which is the column that contains the pre-processed document; Seed, which is used for random number drawing; No of topics, which is the number of topics to detect; No of words per topic, which is the number of top words to extract per topic; No of iterations, which is the number of iterations to perform (influences the runtime of the algorithm); and Alpha, which is the alpha parameter that defines the Dirichlet prior to the per-document topic distributions. It defines the prior weight of topic k in a document. The library uses the given alpha for all topics, normally a number less than 1 (e.g. 0.1), to prefer sparse topic distributions (i.e., few topics per document). Beta, which is the beta parameter, defines the prior on per-topic multinomial distribution over words. It defines the prior weight of word w in a topic. The library uses the given beta for all words. Normally, a number much less than 1 (e.g. 0.001), to strongly prefer sparse word distributions (i.e., few words per topic), and No of threads,

which divides the input document collection into the specified number of threads and merges the calculated statistics afterward [31].

Group-by-component is responsible for grouping the rows of a table by the unique values in the selected group columns. A row is created for each unique set of values of the selected group column [31].

5.3 The Result Obtained from KNIME

I used the same 45 papers as input for the KNIME program. Then, I set the number of topics to 3 topics and 2 words to increase the probability of finding unique topics. The program returned the number of papers for each topic, which resulted in the following:

Topic 0 has two words which are (Students and reading) and 16 papers belong to it.

Topic 1 has two words which are (learning and students) and 14 papers belong to it.

Topic 2 has two words which are (students and student) and 15 papers belong to it.

After getting these topics, I found the mean, standard deviation, and standard error of the mean for each topic. The results of these statistics are illustrated in Figures 5.4-5.6

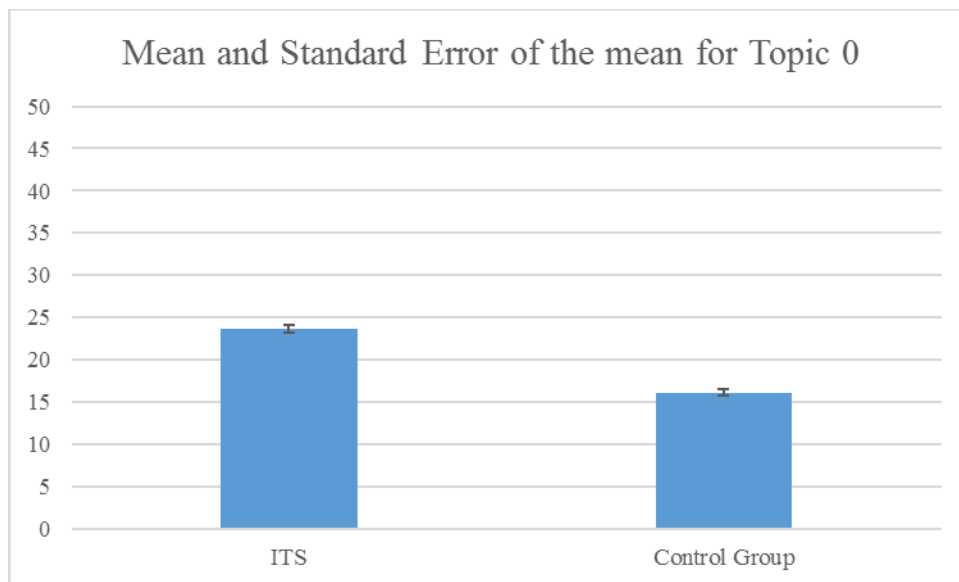


Figure 5.4 The mean and the standard error of the mean for topic 0.

In Figure 5.4, the mean gain score value of students who use ITS for their learning for topic 0 is 23.6, whereas the mean gain score value for students who did not use ITS for topic 0 is 16.1. That means that students who used the ITS in their learning progressed more than students who did not use it. To prove this point, the results of the t-test and one-way ANOVA are illustrated in Tables 3 and 4, respectively.

In Figure 5.5, the mean gain score value of students who did not use ITS for their learning for topic 1 is 11.8, whereas the mean gain score value for students who used ITS is 19.832. This means that students who used the ITS in their learning improved more than students who did not use it. To prove this point, the results of the t-test and one-way ANOVA are illustrated in Tables 3 and 4, respectively.

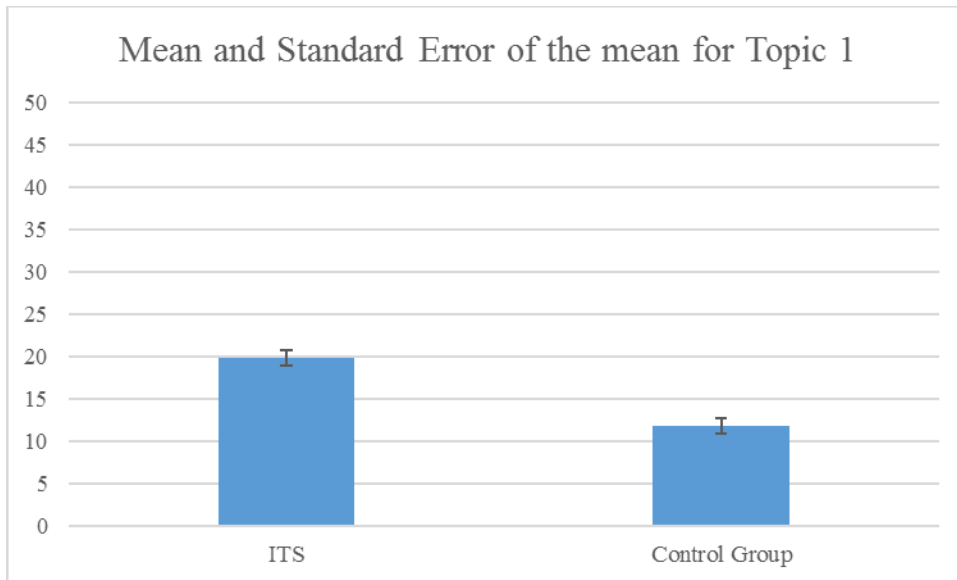


Figure 5.5. The mean and the standard error of the mean for topic 1.

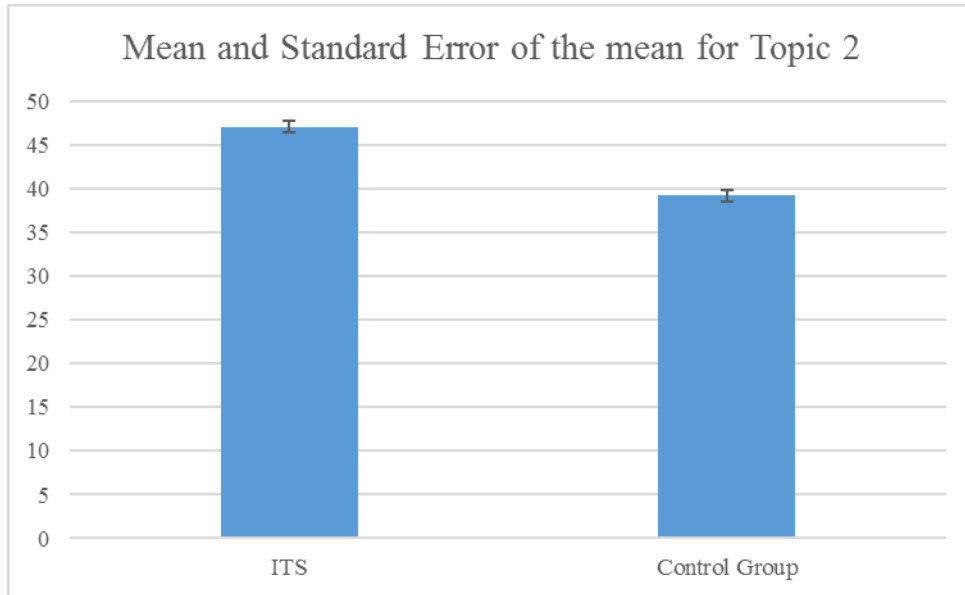


Figure 5.6. The mean and the standard error of the mean for topic 2.

In Figure 5.6, the mean gain score value of students who use ITS for their learning for topic 2 is 47.0, whereas the mean gain score value for students who did not use ITS for topic 2 is 39.2. That means that students who used the ITS in their learning progressed more than students who did not use it. To prove this point, the results of the t-test and one-way ANOVA are illustrated in Tables 3 and 4, respectively.

To analyze these results, first I did the t-test for them, and then the ANOVA test. The obtained results of t-test are presented in Table 3.

Table 3. *T-test for the Topics*

The Topics	Statistical Significance
Topic 0	P<0.0001
Topic 1	P<0.0001
Topic 2	P<0.0001

Table 3 shows that the ITS groups (the groups who learned using ITS) for all topics have mean gain scores higher than the other groups who did not use the ITS in their learning, and they showed a significant improvement in the t-test where their P values were less than 0.0001. These results demonstrate that ITS has a beneficial effect on the students' learning and brings a significant improvement in their performance over time. Table 4 shows that there is a significant improvement in the ANOVA test where their P values were less than 0.000.

Table 4. *ANOVA Test for the Topic*

The Topics	F-value	P-value
Topic 0	146.7	0.000
Topic 1	39.9	0.000
Topic 2	66.0	0.000

After running the KNIME program and getting the above results, I run the program again but I added the most two common words for each topic to the “stop list” so that KNIME would be forced to select the next two most common words for each topic. These words are:

Topic 0: (tutor and study).

Topic 1: (system and knowledge).

Topic 2: (tutoring and andes).

CHAPTER 6: DISCUSSION AND CONCLUSION

6.1 Discussion

This study analyzed 45 papers collected according to a predefined protocol. The results of both t-test and One-way ANOVA of these papers were presented in Chapters 4 and 5 and support the conclusion that ITS causes a significant improvement in learning over traditional classroom instruction. The results of both statistical tests have shown progress of students who used ITS for learning over students who did not use it is highly significant.

In addition to the gain that students achieved using ITS, students also made gains in the retention of the information. According to [32] and [33], the mean value of the retention of information for students who used ITS for learning improved more than students who did not use ITS, as illustrated in Figures 6.1-6.2.

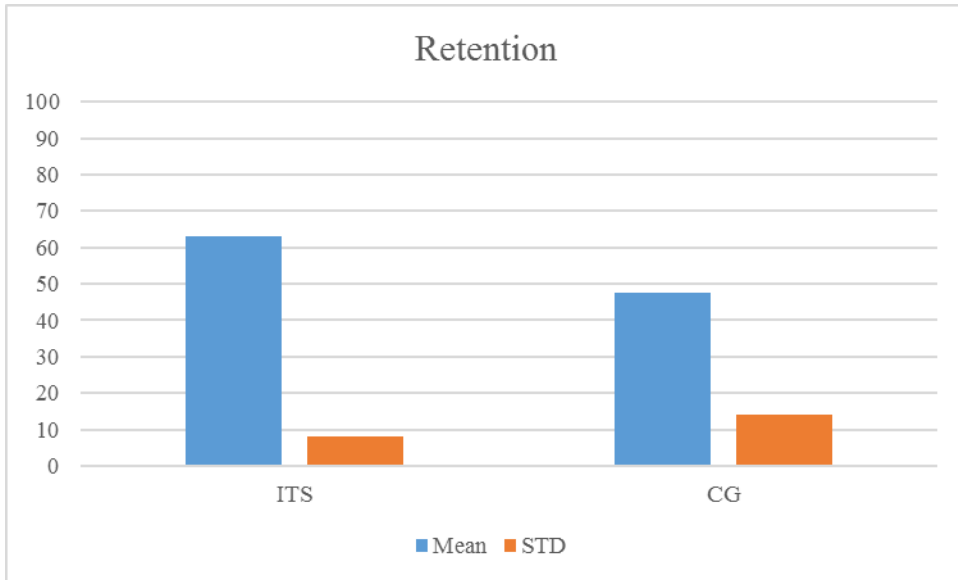


Figure 6.1. Retention [32].

In Figure 6.1, the mean retention value of students who used ITS is more than students who did not use ITS for their learning (i.e., depended on traditional learning) by approximately 15%.

In Figure 6.2, the mean retention value of students who used ITS is more than students who did not use ITS (i.e., depended on traditional learning) by approximately 5%.

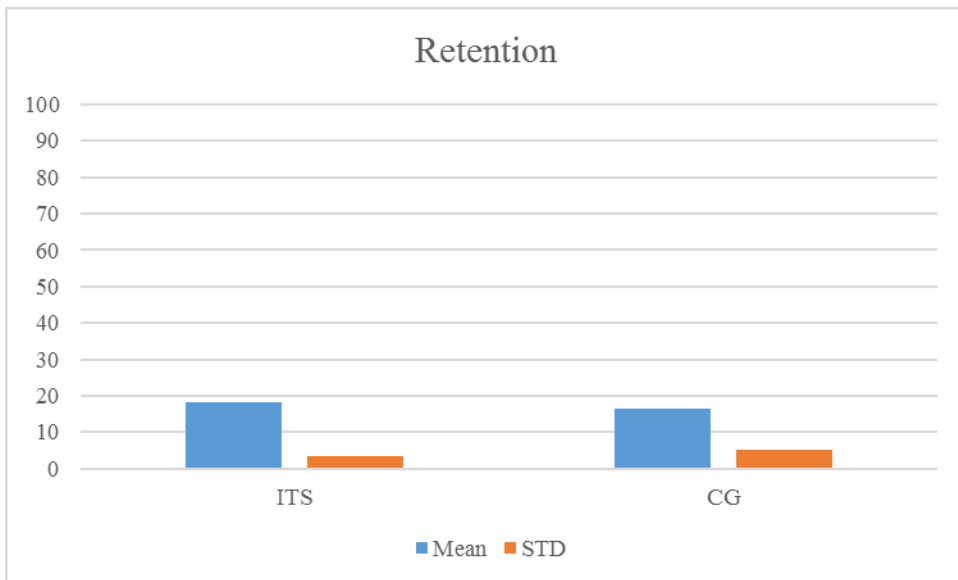


Figure 6.2 Retention for [33]

Another benefit that students experienced from ITS is increased self-confidence. According to [32], [34], [27], and [35], students' self-confidence increased more after using ITS. In [32], the author said that using the ITS helped students raise their self-confidence and become more effective in dealing with their time and developing study habits that improved their learning. The study in [34] showed that students in the ITS class were significantly more confident in their mathematical abilities than students in the other classes who did not use the ITS. In [27], students who used ITS had a significantly higher confidence in learning mathematics than the other group who did not use the ITS. The study in [35] showed that 67% of ITS students increased their motivation for learning mathematics, and 68% of them felt more confident in their abilities to solve math problems.

Besides the increased retention and self-confidence students experienced from ITS, another advantage of ITS is they facilitate learning. According to [36], [29], and [33], students said that using ITS facilitated their learning. In [36], students were asked if the ITS they used facilitated their learning or not. The feedback the author of this paper received indicated that the ITS facilitated learning. The answers of the students also indicated that the ITS they used made it easy to learn. Also in [33], students said that using ITS was more helpful than learning using traditional instructional techniques. The feedback that students got from ITS facilitated their learning process [29]. Students found that their ITS was very well organized. Also, the feedback that they received from it was very useful.

Self-paced learning is an additional feature that ITS introduced to students. As illustrated before, an ITS is software, so there is no rush for students master material a fixed amount of time. In traditional learning methods, teachers have limited time to accommodate varying student abilities when presenting their lectures.

Many studies, [37], [38], [39], and [40], demonstrated that students with remedial skills learned more via ITS than with other methods. In [37], the authors asserted that students who used ITS in their learning and who received low scores on their pre-test exams improved more than stronger students in their post-test exam, as illustrated in Figure 6.3

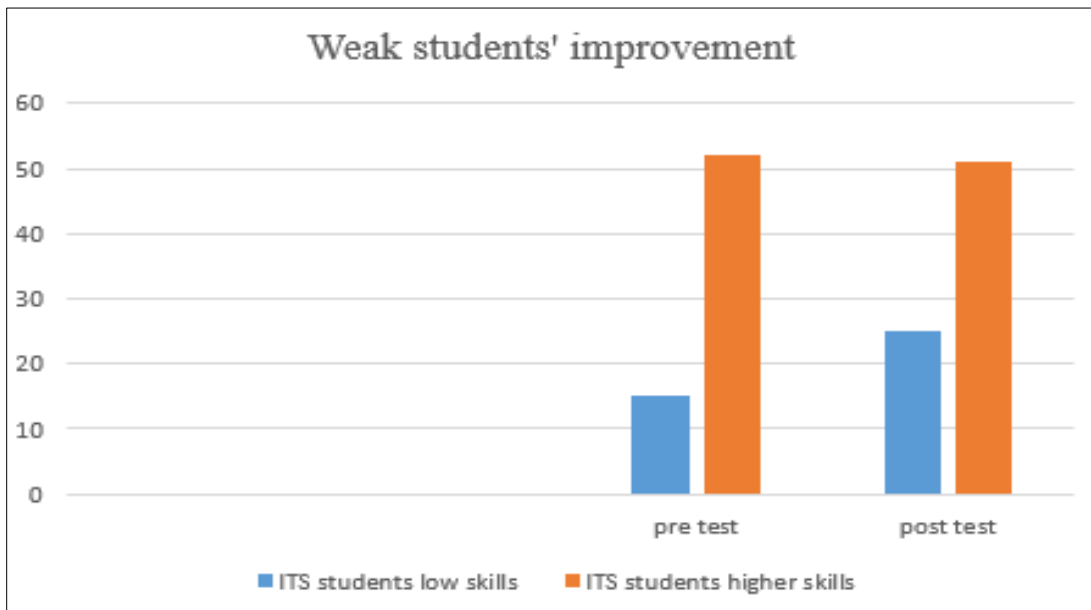


Figure 6.3. Weak students' improvement in study 2 of [37].

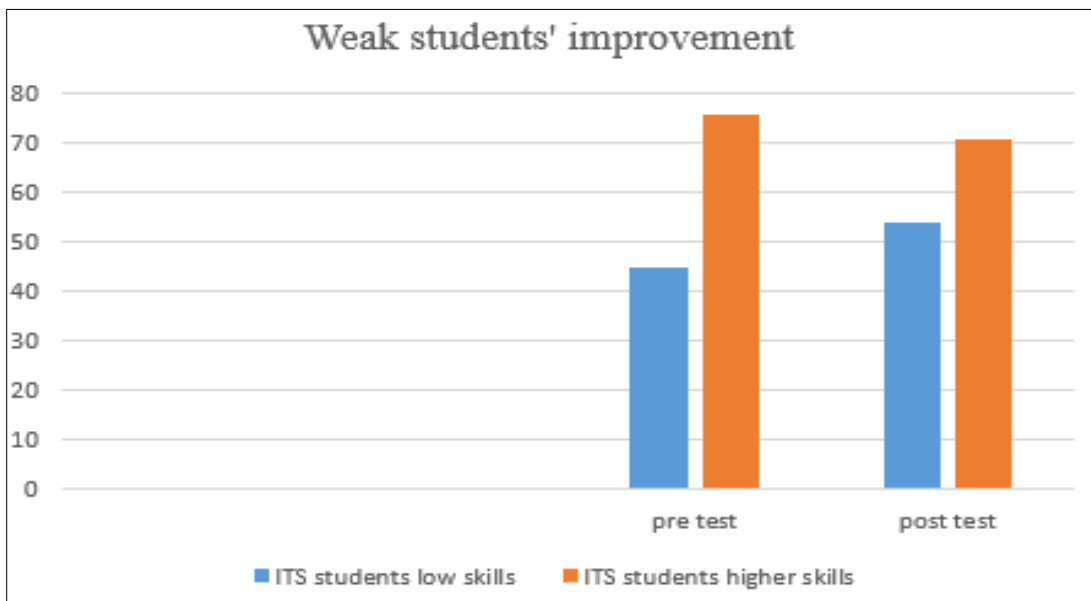


Figure 6.4. Weak students' improvement in study 3 of [37].

In [38], the authors classified the ITS students as strong or weak students depending on their performance in the pre- and post-tests. Their ANOVA results showed that the weak students improved more than stronger students with P value=0.007, but both groups improved by using the ITS in their learning. In [39], the authors said that ITS students with less knowledge performed better when they used the ITS in their learning. Finally, the [40] authors said that students who had low initial skills improved more than students who had high skills.

Despite the results that have been reported in the previous chapter that support the effectiveness of the ITS, there are two papers that argued that students did not improve when they used the ITS. These papers, [41] and [42], showed that students who used ITS in their learning showed no improvement or sometimes negative improvement in their performance.

In [41], the ITS students showed lower performance than other students who used traditional learning methods. This decrease in performance happened because students were not familiar with what the ITS syllabus wanted from them to show their mathematical thinking through frequent group work and class presentations. Also, because the ITS units depended on self-paced lessons, students usually did not take it seriously and did not complete the lessons at the same rate that material was covered in class. Finally, teachers said that students did not learn the material at the rate that teachers were supposed to cover it, in part because of unfamiliarity with the course, and in part because many students lacked baseline skills in algebra and reading, which their ITS teaches, and that they needed to study through the ITS.

The study in [42] showed that even though the results of this paper were promising, the authors expected to get a larger average effect. The reason behind the small or sometimes negative effect is that the ITS's domain knowledge presentation was novel for students, making it difficult to grasp. This means that when students get familiar with the ITS, they should improve.

The KNIME program was also used also on these two papers to explore what words do these papers have in common. The results are as following:

Topic 0: (experiment and experimental).

Topic 1: (students and curriculum).

Topic 2: (level and training).

This thesis depended on just the published studies about the ITS to prove the effectiveness of the ITS. In other words, a lot of researchers publish just the good or positive results of their researches about ITS. It is reasonable to assume that studies with negative results were less like to be published creating a "publication bias" in this study.

6.2 Conclusion

In conclusion, the work reported in this thesis asserted that ITS can be used to help students improve their learning more than traditional instructional methods. This thesis discussed background information about the problems that students face when they use traditional learning methods. Then, the thesis suggested the use of ITS for solving these problems before presenting the research question: "Does the intelligent tutoring system improve students learning abilities more than traditional learning?"

Chapter two described the systematic review used in this thesis and provided historical context for ITS. Furthermore, the chapter explained the main ITS components and provided examples of ITS.

Chapter three described the protocol used to guide the analyses. Chapter four presented the results of the analyses that support the effectiveness of ITS. Chapter five presents the results obtained using LDA and KNIME that also supports the effectiveness of the ITS on the students' learning. Chapter six includes the discussion and conclusions.

6.3 Future Work

For future work, I am planning to build my own ITS that will provide teaching material for people who are seeing or hearing impaired. After finishing the ITS, I will evaluate by collecting data from the students' feedback to see if it is an effective teaching method for the target population.

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Appendix A

45 studies and articles about the effects of intelligent tutoring systems on the learning process were identified. These studies and articles cover different study areas, like case study, empirical study, survey etc. Each one of these studies was read and the context of these studies and their research questions was analyzed. The description of these studies' characteristics and the summary of them are described in the next section.

- Publication year

Table 3 presents the number of the studies and articles that have been published about the effects of intelligent tutoring systems on the learning process from 1990 to 2017.

Table 5 Studies' year of publication and their percent from the whole papers

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998
Paper	1	0	0	0	0	0	0	1	1
Percent	2.13%	0 %	0 %	0 %	0 %	0 %	0 %	2.13%	2.13%
Year	1999	2000	2001	2002	2003	2004	2005	2006	2007
Paper	2	3	3	3	3	2	3	2	5
Percent	4.26%	6.38%	6.38%	6.38%	6.38%	4.26%	6.38%	4.26%	10.64%
Year	2008	2009	2010	2011	2012	2013	2014	2015	2016
Paper	4	6	4	2	0	1	1	0	0
Percent	8.51%	12.75%	8.51%	4.26%	0 %	2.13%	2.13%	0 %	0 %
Year	2017								
Paper	0								
Percent	0 %								

- Studies Summary

To provide summaries for the included studies and articles, a specific form has been identified. This form has information about each study and article. This information includes the following: general information such as study title and the author's name(s), study characteristics such as participant number, inclusion and exclusion criteria of these studies if found, year of the publication, and summary of the studies.

The 45 studies have been summarized and classified based on the above form. In the following pages, I provide summaries about the studies selected for this thesis.

Study 1 [43]:

Name of the study: Evaluating Student Learning Gains in Two Versions of AutoTutor.

- The Authors: Natalie K. Person, Laura Bautista, Arthur C. Graesser, Eric Mathews, and The Tutoring Research Group.
- Participant: 60 students in computer literacy course.
- Country of the study: United states of America.
- Year of the publication: 2001.
- The summary of the paper: This paper talks about the effectiveness of two versions of AutoTutor on the students' learning outcome. Sixty students participated in this study and received tutoring from one of the versions of AutoTutor on one of the following topics: Hardware, Operating Systems, and the Internet. Students were also required to reread material on two of the previously mentioned topics. After that, all participants received a comprehension test on all three topics in this study. A comparison was made between AutoTutor and a reread condition versus a control condition. The results of this study proved that AutoTutor was an effective pedagogical tool compared to the other learning controls. This result showed that the AutoTutor, which is an ITS, has a significant positive impact on students' learning gains compared to other learning conditions.

Study 2 [37]:

- Name of the study: Evaluation of AnimalWatch: An intelligent tutoring system for arithmetic and fractions.
- The Authors: Carole R. Beal, Ivon M. Arroyo, Paul R. Cohen, and Beverly P. Woolf.

- Participants: Grade 6 students in study 1, 149 students in study 2, 60 students in study 3.
- Country of the study: United States of America.
- Year of the publication: 2010.
- The summary of the paper: In this paper, three studies were conducted with middle school students to evaluate a web-based intelligent tutoring system (ITS) for arithmetic and fractions. The studies involved pre and post test comparisons, as well as group comparisons to assess the impact of the ITS on students' math problem solving. The results of these studies have proved that students who used the intelligent tutoring system improved much more from the pretest to post test, while students who did not use the ITS and simply repeated the tests showed no improvement. Also, the results of this study showed that students who had spent more time with the ITS improved more than those who had spent less time with ITS. Improvement was greatest for students with the weakest initial math skills, who were also most likely to use the multimedia help resources for learning that were integrated into the software.

Study 3 [44]:

- Name of the study: Learning Linked Lists: Experiments with the iList System.
- The Authors: Davide Fossati, Barbara Di Eugenio, Christopher Brown, and Stellan Ohlsson.
- Participant: 86 computer science students.
- Country of the study: United States of America.
- Year of the publication: 2008.

- The summary of the paper: This paper presents the first experiments with an Intelligent Tutoring System in the domain of linked lists, a fundamental topic in Computer Science. The system has been deployed in an introductory college-level Computer Science class, and produced significant learning gains. This paper described the architecture of the iList system. This paper proved that students who used the ITS achieved a significant learning gain, while students who did not use the ITS did not gain much.

Study 4 [36]:

- Name of the study: Model-Based Reasoning for Domain Modeling in a Web-Based Intelligent Tutoring System to Help Students Learn to Debug C++ Programs.
- The Authors: Amruth N. Kumar.
- Participants: 52 computer science students.
- Country of the study: United States of America.
- Year of the publication: 2002
- The summary of the paper: This paper analyzed and illustrated the benefits of using Model-Based Reasoning for domain modeling in the context of a Web-based ITS. The system is designed to teach students to analyze and debug C++ programs for semantic and run-time errors. The Authors have evaluated one instance of the Model-Based tutor, which deals with debugging pointers in C++, in several sections of Computer Science II course. This paper proved that students using ITS improved more than students who did not use it.

Study 5 [45]:

- Name of the study: Teaching the Tacit Knowledge of Programming to Novices with Natural Language Tutoring.
- The Authors: H. Chad Lane, and Kurt VanLehn.
- Participants: 25 computer science students.
- Country of the study: United States of America.
- Year of the publication: 2005.
- The summary of the paper: In this paper, the authors tested the efficacy of natural language tutoring to teach and scaffold acquisition of programming skills. They described ProPI, a dialogue-based intelligent tutoring system that elicits goal decompositions and program plans from students in natural language. The system uses a variety of tutoring tactics that leverage students' intuitive understandings of the problem, how it might be solved, and the underlying concepts of programming. They report the results of a small-scale evaluation comparing students who used ProPI with a control group who read the same content. The results of this paper proved that students who received teaching from the ITS improved their ability to solve problems and displayed behaviors that suggest they could think at greater levels of abstraction than students in the read-only group. Also, students who use the ITS scored higher than other who did not use it.

Study 6 [46]:

- Name of the study: Teaching meta-cognitive skills: implementation and evaluation of a tutoring system to guide self-explanation while learning from examples.
- The Authors: Cridtina Conati, and Kurt VanLehn.

- Participants: 56 physics students.
- Country of the study: United States of America.
- Year of the publication: 1999.
- The summary of the paper: This paper described the SE-Coach, which is a tutoring module designed to help students learn effectively from examples through guiding self-explanation, a meta-cognitive-skill that involves clarifying and explaining to oneself the worked-out solution for a problem. In this paper, the author described how the SE-Coach evolved from its original design to the current implementation via an extensive and thorough process of interactive design, based on continuous evaluations with real students. They also present the results of the final laboratory experiments that they have performed with 56 college students. The results of this paper showed that students who used ITS did not make a big significant gain in their achievement over students who did not use the ITS. The reason behind that is students who used the ITS had problems using the system because they did not follow the SE-Coach advice.

Study 7 [47]:

- Name of the study: Exploring the Effectiveness of Knowledge Construction Dialogues.
- The Authors: C. P. Ros e, D. Bhembe, S. Siler, R. Srivastava, and K. VanLehn.
- Participants: 35 physics students.
- Country of the study: United States of America

- Year of the publication: 2003
- The summary of the paper: The goal of the Atlas project has been to provide opportunities for students to construct their own knowledge and to learn actively by conversing with a natural language-based ITS. The authors of this paper reported the results of an evaluation comparing student learning of basic qualitative physics concepts when they engage in natural language dialog, especially in Knowledge Construction Dialogs (KCDs), with student learning when they simply read about the physics concepts in minilessons. This study has proven that the students who used ITS have improved much more than other students who did not use the ITS.

Study 8 [2]:

- Name of the study: An Intelligent SQL Tutor on the Web.
- The Authors: Antonija Mitrovic, and Kurt Hausler.
- Participants: 33 computer science students.
- Country of the study: New Zealand.
- Year of the publication: 2003
- The summary of the paper: In this paper, the authors presented SQLT-Web, which is a Web-enabled intelligent teaching system for the SQL database language. This system observes students' actions and adapts to their knowledge and learning abilities. Constraint-Based Modelling is used to model students. They described the system's architecture in comparison to architectures of other existing Web-enabled tutors. They explained how SQLT-Web deals with multiple students. The results of the evaluation of this system showed that the students have enjoyed the system's adaptability and found it an asset to their learning.

Study 9 [48]:

- Name of the study: An Experimental Evaluation of Logiocando, an Intelligent Tutoring Hypermedia System.
- The Authors: Rosa Lanzilotti, and Teresa Roselli.
- Participants: 71 fourth class pupils.
- Country of the study: Italy.
- Year of the publication: 2007
- The summary of the paper: The authors presented an empirical evaluation of a learning hypermedia with a tutorial component that exploits Artificial Intelligence techniques. This hypermedia, called Logiocando, has been designed for use by a special category of user, namely children of the fourth level of primary school (9-10 years old), to help them to learn basic concepts of logic. The authors also described the aim of this study which was to evaluate the learning effectiveness of Logiocando and to estimate the difference between two approaches: computer-based using a hypermedia system, and traditional, namely a typical lesson in the classroom. The results have shown that students who use the ITS enhanced their knowledge more than other who did not use the ITS.

Study 10 [38]:

- Name of the study: An intelligent tutoring system for the accounting cycle: Enhancing textbook homework with artificial intelligence.
- The Authors: Benny G. Johnson, Fred Phillips, and Linda G. Chase.
- Participants: 55 accounting students.
- Country of the study: United States of America.

- Year of the publication: 2009.
- The summary of the paper: This paper described an electronic tutoring system, developed using principles of artificial intelligence (AI), to help students learn the accounting cycle. To assess the effectiveness of the tutoring system, the authors administered a pre-test and then required students in a sophomore accounting course to use either the tutoring system or their textbook as a reference when journalizing transactions for a homework assignment. The results showed that the tutor group's test performance increased approximately 27% points, whereas the textbook group's test performance improved by only 8% points.

Study 11 [29]:

- Name of the study: Evaluating an Intelligent Tutoring System for Design Patterns: the DEPTHS Experience.
- The Authors: Zoran Jeremić1, Jelena Jovanović1 and Dragan Gašević.
- Participants: 42 software development students.
- Country of the study: Serbia.
- Year of the publication: 2009
- The summary of the paper: This paper described the evaluation study of DEPTHS, an intelligent tutoring system for learning software design patterns. The study which took place during the spring semester 2006 was aimed at assessing the system's effectiveness and the accuracy of the applied student model. It also targeted the evaluation of the students' subjective experiences with the system. The results of this paper showed that the students who use ITS improved and their outcomes were enhanced.

Study 12 [32]:

- Name of the study: Evaluating the Effectiveness of the CPP-Tutor, an Intelligent Tutoring System for Students Learning to Program in C++.
- The Authors: Samy S. Abu Naser.
- Participants: 62 C++ students.
- Country of the study: Palestine.
- Year of the publication: 2009
- The summary of the paper: In this paper, the author described an experiment in which he tried to measure the effectiveness of the CPP-Tutor. This was accomplished by comparing the traditional method of teaching (instructor and textbook) and CPP-Tutor of an introductory course in C++ programming to freshman students in the faculty of Engineering and Information Technology of Al-Azhar University in Gaza. A group of students were taught C++ programming concepts using CPP-Tutor and a second group was taught the same concepts in parallel by traditional methods of teaching. Both groups were coordinated for similar background knowledge of the topics being taught. Post testing revealed that the CPP-Tutor group achieved significantly higher scores than the group taught using the traditional method. Furthermore, The CPP-Tutor group showed that the retention of specific topic of knowledge was better than the traditional method group.

Study 13 [42]:

- Name of the study: Controlled experiment replication in evaluation of e-learning system's educational influence.

- The Authors: Ani Grubišić, Slavomir Stankov, Marko Rosic, and Branko Z itko.
- Participants: 302 chemical and science students.
- Country of the study: Croatia.
- Year of the publication: 2009
- The summary of the paper: This paper presented the methodology for conducting controlled experiment replication, as well as results of a controlled experiment and an internal replication that investigated the effectiveness of intelligent authoring shell eXtended Tutor–Expert System (xTEEx-Sys). The initial and the replicated experiment were based on the authors’ approach that combines classical two-group experimental design with factorial? design. They call it a pre-and-posttest control group experimental design with checkpoint-tests. The results of this paper showed that students who used ITS did not improve as the authors expected. This is because domain knowledge presentation was rather novel for students and therefore difficult to grasp and apply in earlier phases of the experiment.

Study 14 [33]:

- Name of the study: The Impact of a Peer-Learning Agent Based on Pair Programming in a Programming Course.
- The Authors: Keun-Woo Han, EunKyoung Lee, and YoungJun Lee.
- Participants: 115 high school students.
- Country of the study: Korea.
- Year of the publication: 2010.
- The summary of the paper: This paper analyzed the educational effects of a peer-learning agent based on pair programming in programming courses. A peer-

learning agent system was developed to facilitate the learning of a programming language using pair programming strategies. The peer-learning agent uses artificial intelligence. This paper developed a model for determining students' programming abilities. In addition, the roles of the tutor and tutee are like the roles of a navigator and driver in pair programming. The developed agent system is demonstrated to have positive effects on knowledge retention and transfer in a programming course, with a greater influence on transfer than on retention. This model combining peer-learning agents with a teaching and learning strategy was more effective in helping learners to acquire programming skills.

Study 15 [49]:

- Name of the study: An intelligent tutoring system that generates a natural language dialogue using dynamic multi-level planning.
- The Authors: Chong Woo Woo, Martha W. Evens, Reva Freedman, Michael Glass, Leem Seop Shim, Yuemei Zhang, Yujian Zhou, and Joel Michael.
- Participants: 50 medical students.
- Country of the study: United States of America.
- Year of the publication: 2006
- The summary of the paper: This research objective was to build an intelligent tutoring system capable of carrying on a natural language dialogue with a student who is solving a problem in physiology. The authors analyzed of a corpus of 75 hour-long tutoring sessions carried on in keyboard-to- keyboard style by two

professors of physiology at Rush Medical College tutoring first-year medical students provided the rules used in tutoring strategies and tactics, parsing, and text generation. The authors described the architecture of the system. The results of experiments with pretests and posttests have shown that using the ITS for an hour produces significant learning gains and that even this brief use improves the student's ability to solve problems more than reading textual material on the topic.

Study 16 [34]:

- Name of the study: An experimental study of the effects of Cognitive Tutor Algebra I on student knowledge and attitude.
- The Authors: Pat Morgan, and Steven Ritter.
- Participants: 3180 ninth grade students.
- Country of the study: United States of America.
- Year of the publication: 2002.
- The summary of the paper: In 2000/2001 this study was conducted to understand the effectiveness of the Cognitive Tutor Algebra I on high school students. There were 3180 high ninth grade students who participated in this study. The results showed that student who used the ITS achieved better results than other students, and they felt more confidence.

Study 17 [50]:

- Name of the study: An intelligent tutor for intrusion detection on computer systems.
- The Authors: Neil C. Rowe, and Sandra Schiavo.
- Participants: 38 computer security students.
- Country of the study: United States of America.

- Year of the publication: 1998.
- The summary of the paper: This paper talked about intrusion detection which is the process of identifying unauthorized usage of a computer system. The authors described a tutor incorporating two programs. The first program uses artificial-intelligence planning methods to generate realistic audit files reporting actions of a variety of simulated users (including intruders) of a Unix computer system. The second program simulates the system afterwards, and asks the student to inspect the audit and fix the problems caused by the intruders. Experiments showed that students using the tutor learn a significant amount in a short time.

Study 18 [51]:

- Name of the study: A Large-Scale Evaluation of an Intelligent Discovery World: Smithtown.
- The Authors: Valerie J. Shute.
- Participants: 30 economic students.
- Country of the study: United States of America.
- Year of the publication: 1990.
- The summary of the paper: the author talked about Smithtown which is an intelligent tutoring system designed to enhance an individual's scientific inquiry skills as well as to provide an environment for learning principles of basic microeconomics. This paper presented an evaluation of Smithtown in two studies of individual differences in learning. Experiment 1, an exploratory study, demonstrated that Smithtown fared very well when compared to traditional instruction on economics and delineated the performance indicators which

separated better from worse learners in this discovery environment. Experiment 2 extended the findings from the exploratory study using a large sample of subjects from a different population interacting with Smithtown and showed that the performance indicators relating to hypothesis generation and testing were the most predictive of successful learning in Smithtown, accounting for considerably more of the variance in our learning criterion than a measure of general intelligence. The results showed that students learn faster when they used ITS.

Study 19 [52]

- Name of the study: Tutoring Bilingual Students with an Automated Reading Tutor That Listens: Results of a Two-Month Pilot Study.
- The Authors: Robert Poulsen.
- Participants: 586 fourth grade Hispanic students.
- Country of the study: United States of America.
- Year of the publication: 2004
- The summary of the paper: A two-month pilot study comprised of 34 second through fourth grade Hispanic students from four bilingual education classrooms was conducted to compare the efficacy of the 2004 version of the Project LISTEN Reading Tutor against the standard practice of sustained silent reading (SSR). The results showed that students who use the ITS gained more than students who did not use the ITS.

Study 20 [53]:

- Name of the study: Intelligent Tutoring Goes to School in the Big City.
- The Authors: Kenneth R. Koedinger, and John R. Anderson.

- Participants: 470 high school students.
- Country of the study: United States of America.
- Year of the publication: 1997.
- The summary of the paper: This paper reported on a large-scale experiment introducing and evaluating intelligent tutoring in an urban High School setting. The authors have built an intelligent tutor, called PAT that has been made a regular part of 9th grade Algebra in 3 Pittsburgh schools. In the 1993-94 school year, the authors evaluated the effect of the PUMP curriculum, which is Pittsburgh Urban Mathematics Project, and PAT tutor use. The results of this study showed that on average the 470 students in experimental classes outperformed students in comparison classes by 15% on standardized tests and 100% on tests targeting the PUMP objectives.

Study 21 [54]:

- Name of the study: Computer-Guided Oral Reading Versus Independent Practice: Comparison of Sustained Silent Reading to an Automated Reading Tutor that Listens.
- The Authors: JACK MOSTOW, and JOSEPH E. BECK.
- Participants: 178 1-4 grade students.
- Country of the study: United States of America.
- Year of the publication: 2013.
- The summary of the paper: A 7-month study of 178 students in grades 1-4 at two Blue Ribbon schools compared two daily 20-minute treatments. Eighty-eight students used the 2000-2001 version of Project LISTEN's Reading Tutor in 10-

computer labs, averaging 19 hours over the course of the year. The Reading Tutor listened to students read aloud, giving spoken and graphical help when it noticed them click for help, make a mistake, or get stuck. The results of this study showed that students who used the Reading Tutor averaged significantly higher gains across measures of reading ability, especially those involving word level skills than their matched classmates who spent that time doing Sustained Silent Reading (SSR) in their classrooms. Additionally, these students trended toward higher gains in fluency and reading comprehension.

Study 22 [27]:

- Name of the study: Evaluation of the Cognitive Tutor Algebra I Program.
- The Authors: Alex Shneyderman.
- Participants: 777 algebra high school students.
- Country of the study: United States of America.
- Year of the publication: 2001.
- The summary of the paper: this paper talked about the evaluation of Carnegie Learning's Cognitive Tutor Algebra I program which is designed to provide students with an opportunity to learn Algebra I in both classroom and computer lab settings. Within the Miami-Dade County Public Schools, the program was used in nine senior high schools during the 2000-2001 school year. The Division of Mathematics and Science requested this evaluation of the 2000-2001 Cognitive Tutor Algebra I program to investigate effects of the program on student learning. Two student groups, the Program and Comparison Samples, were established. The results showed that the passing rate and the final grades for students who used the

ITS were higher than others. Also, students who used the ITS had a higher confidence about learning mathematics than others.

Study 23 [55]:

- Name of the study: I learn from you, you learn from me: How to make iList learn from students.
- The Authors: Davide FOSSATI, Barbara DI EUGENIO, Stellan OHLSSON, Christopher BROWN, Lin CHEN, and David COSEJO.
- Participants: 243 computer science students.
- Country of the study: United States of America.
- Year of the publication: 2009.
- The summary of the paper: The authors developed a new model for iList, which is a system that helps students learn a linked list. The model is automatically extracted from past student data, and allows iList to track students' problem-solving behavior to provide targeted feedback. They evaluated the new model both intrinsically and extrinsically. Also, they showed that the model can match most student actions after a relatively small sequence of observations, and that iList can effectively use the new student tracker to provide feedback and help students learn. The results showed that the performance of iList was very respectful respectable? compared to the human tutor.

Study 24 [56]:

- Name of the study: Evaluating a web based intelligent tutoring system for mathematics at German lower secondary schools.
- The Authors: Martin Graff & Peter Mayer, and Morena Lebens.

- Participants: 4-6 grade pupils.
- Country of the study: Germany.
- Year of the publication: 2008.
- The summary of the paper: This study researched the implementation of a web based intelligent tutoring system for mathematics at lower secondary schools. To improve the basic mathematical skills in lower secondary school children, several schools implemented the web based intelligent tutoring system eFit. The authors' aim of this research was to investigate whether eFit constitutes an effective intervention of this target group. The results showed that compared to a non-treatment control group, children in the eFit group significantly improved their arithmetic performance over a period of 9 months.

Study 25 [57]:

- Name of the study: Research Methods Tutor: Evaluation of a dialogue-based tutoring system in the classroom.
- The Authors: Elizabeth Arnott, Peter Hastings, and David Allbritton.
- Participants: 136 psychology research methods course students.
- Country of the study: United States of America.
- Year of the publication: 2008.
- The summary of the paper: Research Methods Tutor (RMT) is a dialogue-based intelligent tutoring system for use in conjunction with undergraduate psychology research methods courses. The authors evaluated the effectiveness of the RMT system in the classroom using a nonequivalent control group design. The results showed that the use of RMT produced strong learning gains above classroom

instruction alone. Further, the dialogue-based tutoring condition of the system resulted in higher gains than did the textbook-style condition.

Study 26 [58]:

- Name of the study: Why/AutoTutor: A Test of Learning Gains from a Physics Tutor with Natural Language Dialog.
- The Authors: Graesser, A.C.1, Jackson, G.T. 1., Mathews, E.C.1, Mitchell, H.H.1, Olney, A.1, Ventura, M.1, Chipman, P.1, Franceschetti, D.1, Hu, X.1, Louwerse, M.M.1, Person, N.K.2, and the Tutoring Research Group1.
- Participants: 67 physics students.
- Country of the study: United States of America.
- Year of the publication: 2003.
- The summary of the paper: Why/AutoTutor is a tutoring system that helps students construct answers to qualitative physics problems by holding a conversation in natural language. Why/AutoTutor provides feedback to the student on what the student types in (positive, neutral, negative feedback), pumps the student for more information, prompts the student to fill in missing words, gives hints, fills in missing information with assertions, identifies and corrects bad answers and misconceptions, answers students' questions, and summarizes answers. The authors conducted an experiment that compared Why/AutoTutor with two control conditions (Read textbook, nothing) in assessments of learning gains. The results

showed that the tutoring system performed significantly better than the two control conditions.

Study 27 [59]:

- Name of the study: Diagnosing student learning problems based on historical assessment records.
- The Authors: Gwo-Jen Hwang, Judy C.R. Tseng, and Gwo-Haur Hwang.
- Participants: 140 high school students studying mathematics.
- Country of the study: Taiwan.
- Year of the publication: 2008.
- The summary of the paper: This study proposes an algorithm for diagnosing students' learning problems and provides personalized learning suggestions for Science and Mathematics courses. An intelligent tutoring, evaluation and diagnosis system has been implemented based on the novel approach. The results of this study have shown that students who use the ITS achieved more than other students and enhanced their learning performance.

Study 28 [60]:

- Name of the study: Evaluating the Effectiveness of a Cognitive Tutor for Fundamental Physics Concepts.
- The Authors: Patricia L. Albacete, and Kurt A. VanLehn.
- Participants: 42 mechanics students.
- Country of the study: United States of America.
- Year of the publication: 2000.

- The summary of the paper: In this study, the authors described and analyzed the evaluation of the Conceptual Helper which is an intelligent tutoring system that uses a unique cognitive approach to teaching qualitative physics. The results of this study showed that the ITS is an effective tool and suggest that the proposed methodology can be operative in performing its task.

Study 29 [61]:

- Name of the study: Andes: An Active Learning, Intelligent Tutoring System for Newtonian Physics.
- The Authors: Kay G. Schulze, Robert N. Shelbyz, Donald J. Treacy, Mary C. Wintersgillz, and Kurt Vanlechn.
- Participants: 334 physics students.
- Country of the study: United States of America.
- Year of the publication: 2000.
- The summary of the paper: This paper talked about Andes which is an intelligent tutoring system in classical physics that has been in development by researchers at the Learning Research, and Development Center (LRDC) at the University of Pittsburgh and the United States Naval Academy since 1996. The authors also talked about Andes architecture. The authors evaluated this ITS and the results showed that Andes is better for learning than the traditional classroom.

Study 30 [62]:

- Name of the study: A Method for Learning Scenario Determination and Modification in Intelligent Tutoring Systems.

- The Authors: ADRIANNA KOZIERKIEWICZ-HETMAN´SKA, NGOC THANH NGUYEN.
- Participant: 70 students.
- Country of the study: Poland.
- Year of the publication: 2011.
- The summary of the paper: In this paper, a concept of an intelligent e-learning system has been proposed. The authors talked about the main purpose of this system which is to teach effectively by providing an optimal learning path in each step of the educational process. The results of this study showed that students who used the ITS achieved and scored better than other students who did not use it.

Study 31 [63]:

- Name of the study: Improving Child Literacy in Africa: Experiments with an Automated Reading Tutor.
- The Authors: G. Ayorkor Korsah, Jack Mostow, and M. Bernardine Dias.
- Participants: 89 grade 2-4 pupils in Ghana and 11 grade 2-4 pupils in Zambia.
- Country of the study: Ghana and Zambia.
- Year of the publication: 2010.
- The summary of the paper: The authors of this paper described project Kané which is a research endeavor aimed at exploring the role that technology can play in improving child literacy in developing communities. They did an initial pilot study and a subsequent four-month-long controlled field study in Ghana and Zambia investigating the viability and effectiveness of an automated reading tutor in helping urban children enhance their reading skills in English. The results of this

study proved that using the reading tutor, which is an ITS, improved the students' learning a lot.

Study 32 [39]:

- Name of the study: Improving Adolescent Students' Reading Comprehension with iSTART.
- The Authors: DANIELLE S. MCNAMARA, TENAHA P. O'REILLY, RACHEL M. BEST, and YASUHIRO OZURU.
- Participants: 39 grade 8-9.
- Country of the study: United States of America.
- Year of the publication: 2006.
- The summary of the paper: This study examined the benefits of reading strategy training on adolescent readers' comprehension of a science text. Training was provided via an automated reading strategy trainer called the Interactive Strategy Trainer for Active Reading and Thinking (iSTART), which is an interactive reading strategy trainer that utilizes animated agents to provide reading strategy instruction. Half of the participants were provided with iSTART while the others (control) were given a brief demonstration of how to self-explain text. This study showed that adolescents with less prior knowledge about reading strategies performed significantly better on text-based questions if they received iSTART training. Also, for high-strategy knowledge students, iSTART improved comprehension for bridging inference questions.

Study 33 [40]:

- Name of the study: On-line Tutoring for Math Achievement Testing: A Controlled Evaluation.
- The Authors: Carole R. Beal, and Rena Walles, Ivon Arroyo, and Beverly P. Woolf.
- Participants: 202 high school students.
- Country of the study: United States of America.
- Year of the publication: 2007.
- The summary of the paper: The authors described the results of a controlled evaluation of an interactive on-line tutoring system for high school math achievement test problem solving. High school students (N = 202) completed a math pre-test and were then assigned by teachers to receive interactive on-line multimedia tutoring or their regular classroom instruction. The on-line tutored students improved on the post-test, but the effect was limited to problems involving skills tutored in the on-line system (within-group control). On the other hand, control group students showed no improvement. Students with weakest initial math skills showed higher improvement.

Study 34 [64]:

- Name of the study: Evaluation of a Constraint-Based Tutor for a Database Language.
- The Authors: Antonija Mitrovic, and Stellan Ohlsson.
- Participants: 20 computer science students.
- Country of the study: New Zealand.
- Year of the publication: 1999.

- The summary of the paper: The authors proposed a novel approach to intelligent tutoring in which feedback messages are associated with constraints on correct problem solution. Constraint-based tutoring has been implemented in SQL-Tutor which is an intelligent tutoring system for teaching the database query language SQL. The evaluation of this system showed that (a) students find the system easy to use, and (b) they do better on a subsequent classroom examination than peers without experience with the system.

Study 35 [65]:

- Name of the study: The Andes Physics Tutoring System: Lessons Learned.
- The Authors: Kurt VanLehn, Collin Lynch, Kay Schulze, Joel A. Shapiro, Robert Shelby, Linwood Taylor, Don Treacy, Anders Weinstein, and Mary Wintersgill.
- Participants: 1066 physics students.
- Country of the study: United States of America.
- Year of the publication: 2005.
- The summary of the paper: In this paper, the authors showed that Andes system can demonstrate that student learning can be significantly increased by upgrading only their homework problem-solving support. Although Andes is called an intelligent tutoring system, it replaces only the students' pencil and paper as they do problem-solving homework. They did five years of experimentation at the United States Naval Academy and these indicated that Andes significantly improves student learning.

Study 36 [66]:

- Name of the study: What Evidence Matters? A randomized field trial of Cognitive Tutor Algebra I.
- The Authors: Steven Ritter, Jonna Kulikowichb, Pui-Wa Lei, Christy L. McGuire, Pat Morgan.
- Participants: 659 ninth grade students.
- Country of the study: United States of America.
- Year of the publication: 2007.
- The summary of the paper: This paper showed the results of a rigorous evaluation of the Cognitive Tutor Algebra I curriculum, which is substantially based on an intelligent tutoring system. The result of this paper showed that students who use the ITS learn better than others who did not use it.

Study 37 [67]:

- Name of the study: Research Results of Cognitive Tutor.
- The Authors: Carnegie Learning.
- Participants: 480 freshman students.
- Country of the study: United States of America.
- Year of the publication: 2001.
- The summary of the paper: During the 2000-2001 school year, students attending the Freshman Academy in Canton City Schools used either Cognitive Tutor Algebra I or Interactive Mathematics Program (IMP) curriculum in their math courses. The results of this paper showed that course passing rates were higher among the students using the Cognitive Tutor than the IMP students. Additionally, student and teacher surveys indicated that both students and teachers held a higher

opinion of the Cognitive Tutor than IMP and were more likely to feel the curriculum they used should be used for future students.

Study 38 [68]:

- Name of the study: ASPIRE: An Authoring System and Deployment Environment for Constraint-Based Tutors.
- The Authors: Antonija Mitrovic, Brent Martin, Pramuditha Suraweera, Konstantin Zakharov, Nancy Milik, Jay Holland.
- Participants: 21 Accounting and Finance students.
- Country of the study: New Zealand.
- Year of the publication: 2009.
- The summary of the paper: The authors talked about their tutors which have proven their effectiveness not only in controlled lab studies but also in real classrooms, and some of them have been commercialized. This paper presented ASPIRE (Authoring Software Platform for Intelligent Resources in Education), a complete authoring and deployment environment for constraint-based ITSs. The authors described the architecture of this ITS. They discussed the authoring process and illustrated it using the development process of CIT which is an ITS that teaches capital investment decision making. The results showed that the ITS can help student enhancing their learning ability.

Study 39 [69]:

- Name of the study: The Andes Physics Tutoring System: Five Years of Evaluations.

- The Authors: Kurt VANLEHN, Collin Lynch, Kay Schulze, Joel A. Shapiro, Robert Shelby, Linwood Taylor, Don Treacy, Anders Weinstein, and Mary Wintersgill.
- Participants: 1066 physics students.
- Country of the study: United States of America.
- Year of the publication: 2005.
- The summary of the paper: The authors talked about Andes which is a mature intelligent tutoring system that has helped hundreds of students improve their learning of university physics. It replaces pencil and paper problem solving homework. Students continue to attend the same lectures, labs and recitations. This paper talked about five years of experimentation at the United States Naval Academy, and these experimentations indicated that it significantly improves student learning.

Study 40 [41]:

- Name of the study: An Experiment to Evaluate the Efficacy of Cognitive Tutor Geometry.
- The Authors: John F. Pane, Daniel F. McCaffrey, and Mary Ellen Slaughter.
- Participants: 699 high school students.
- Country of the study: United States of America.
- Year of the publication: 2010.
- The summary of the paper: This paper estimated the causal impact of a technology-based geometry curriculum on students' geometry achievement, as well as their attitudes toward mathematics and technology. The curriculum combines learner

centered classroom pedagogy with individualized, computer-based student instruction. The authors did an experiment over a 3-year period in eight high schools within an urban fringe district. The results found that students assigned to the treatment curriculum scored 19% of a standard deviation lower on the geometry posttest than their counterparts assigned to the district's standard curriculum, but found no statistically significant impact on students' attitudes toward mathematics and technology.

Study 41 [70]:

- Name of the study: Improving Content Area Reading Comprehension with 4-6th Grade Spanish Ells Using Web-Based Structure Strategy Instruction.
- The Authors: Dr. Kausalai (Kay) Wijekumar¹, Dr. Bonnie J.F. Meyer and Dr. Puiwa Lei.
- Participants: grade 4, 5, and 6 students.
- Country of the study: United States of America.
- Year of the publication: 2014.
- The summary of the paper: This paper talked about Structure strategy instruction on the Web for English Language Learners (SWELL) is a web-based tutoring system that supports students in reading comprehension by teaching them about five text structures. The authors described SWELL which can provide two adaptations for students – Spanish and English Hybrid, where students were given the option of seeking assistance in Spanish by hovering over words. In this paper, the authors reported on the design and pilot studies conducted within five

classrooms at grades 4, 5, and 6. The results showed improvements in reading comprehension measured by researcher design measures.

Study 42 [35]:

- Name of the study: On the Design and Use of a Cognitive Tutoring System in the Math Classroom.
- The Authors: Ignacio Casas, Paul S. Goodman, and Enrique Pelaez.
- Participants: 1054 students from Chile, 396 students from Ecuador, 354 students from Mexico, and 100 students from El Salvador.
- Country of the study: Chile, Ecuador, Mexico, El Salvador.
- Year of the publication: 2011
- The summary of the paper: The authors talked about MCT-LAC which is a Math Cognitive Tutor System, and it consists of a teaching-learning strategy based on “learning by doing”, which is enhanced using an interactive software tool that adapts itself to the student’s interactions and responses. The strategy uses both an individual approach (in the computer lab) and a collaborative approach (in the classroom). Also, the authors talked about the architecture of the MCT-LAC software. As a side effect, the MCT-LAC system also serves as an excellent tool for teachers to re-enforce their math knowledge and associated teaching strategies. In this paper, they described the strategy and tools of the MCTLAC system. The results of this study showed that students who use the ITS improved a lot.

Study 43 [71]:

- Name of the study: Supporting collaborative learning and problem-solving in a constraint-based CSCL environment for UML class diagrams.
- The Authors: Nilufar Baghaei & Antonija Mitrovic & Warwick Irwin.
- Participants: 48 software engineering students.
- Country of the study: New Zealand.
- Year of the publication: 2007.
- The summary of the paper: The authors presented COLLECT-UML which is a constraint-based intelligent tutoring system (ITS) that teaches object-oriented analysis and design using Unified Modelling Language (UML). UML is easily the most popular object-oriented modelling technology in current practice. They started by developing a single-user ITS that supported students in learning UML class diagrams. The system was evaluated in a real classroom, and the results showed that students' performance increased significantly. In this paper, the authors presented their experiences in extending the system to provide support for collaboration as well as domain-level support. They described the architecture, interface and support for collaboration in the new, multi-user system. The effectiveness of the system has been evaluated in two studies. In addition to improved problem-solving skills, the participants both acquired declarative knowledge about effective collaboration and did collaborate more effectively. The participants have enjoyed working with the system and found it an asset to their learning.

Study 44 [72]:

- Name of the study: Intelligent Interactive Tutoring System for Engineering Mechanics.
- The Authors: C. K. Soh' and Ashok Gupta.
- Participants: 1600 engineering mechanics students.
- Country of the study: Singapore.
- Year of the publication: 2000.
- The summary of the paper: The authors have developed an Intelligent Interactive Tutoring System for engineering mechanics for the first-year engineering students at the Nanyang Technological University, Singapore. The main objective of this system was to supplement classroom teaching via intelligent interaction with the computer-based tutoring system. This system is designed to be a self-paced virtual tutor with intelligent, user-friendly interactions. It is intended to be different from the many commercially available computerized textbooks. The evaluation has been done with 200 students who had earlier failed the course in the first semester and repeated it in the second semester of academic year 1997-1998. The system received good response from the students.

Study 45 [73]:

- Name of the study: Tutoring Bilingual Students with an Automated Reading Tutor that Listens.
- The Authors: ROBERT POULSEN, PETER HASTINGS, DAVID ALLBRITTON.
- Participants: 34 Hispanic students.
- Country of the study: United States of America.

- Year of the publication: 2007.
- The summary of the paper: This article compared the classroom standard practice of sustained silent reading with the Project LISTEN Reading Tutor which uses automated speech recognition to “listen” to children read aloud, providing both spoken and graphical feedback. In this study, 34 Hispanic students spent one month in the classroom and one month using the Reading Tutor for 25 minutes per day. The results of this study showed that the Reading Tutor condition produced significant learning gains in several measures of fluency. These dramatic results from a one-month treatment indicate this technology may have much to offer English language learners.